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# CCITT

# Q.922

THE INTERNATIONAL
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**DIGITAL SUBCRIBER SIGNALLING
SYSTEM No. 1 (DSS 1)
DATA LINK LAYER**

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## ISDN DATA LINK LAYER SPECIFICATION FOR FRAME MODE BEARER SERVICES

**Recommendation Q.922**

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Geneva, 1992

## FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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CCITT NOTE

In this Recommendation, the expression “Administration” is used for conciseness to indicate both a telecommunication Administration and a recognized private operating agency.

**Recommendation Q.922**

## ISDN DATA LINK LAYER SPECIFICATION FOR FRAME MODE BEARER SERVICES

CONTENTS

1 General

2 Frame structure for peer-to-peer communication

3 Elements of procedures and formats of fields for data link layer peer-to-peer communication

4 Elements of layer-to-layer communication

5 Definition of the peer-to-peer procedures of the data link layer

*Annex A* – Core aspects of Recommendation Q.922 for use with frame relaying bearer service

*Annex B* – SDL for point-to-point procedures

*Appendix I* – Responses to network congestion

*Appendix II* – Signalling configurations

*Appendix III* – Automatic negotiation of data link layer parameters

*Appendix IV* – A convergence protocol to provide OSI CONS above Recommendation Q.922

*Appendix V* – Occurrence of MDL-ERROR indication within the basic states

*Appendix VI* – Abbreviations and acronyms used in this Recommendation

*References*

## 1 General

This Recommendation specifies the frame structure, elements of procedure, format of fields and procedures of the data link layer to support frame mode bearer services in the user plane as defined in Recommendation I.233 [1].

This specification of a data link layer protocol and procedures for frame mode bearer services is based upon and is an extension of the LAPD (Link access procedure on the D-channel) protocol and procedures defined in Recommendation Q.921 [2]. The procedures are applicable to, but not restricted to, access a Frame Mode Bearer Service and are also designated link access procedures to frame mode bearer services, or LAPF. A subset of LAPF, corresponding to the data link core sublayer (as defined in Recommendation I.233), is used to support the Frame Relaying Bearer service. This subset is named "data link core protocol" (DL-CORE) and is provided in Annex A. The remainder of the LAPF is called the data link control (DL-CONTROL) protocol.

The purpose of the LAPF is to convey data link service data units between DL-service users in the U-plane for frame mode bearer services across the ISDN user-network interface on B-, D- or H-channels. Frame mode bearer connections are established using either procedures specified in Recommendation Q.933 [3] or (for permanent virtual circuits) by subscription.

LAPF uses a physical layer service, as supported by the I.430 [4] Series Recommendations. LAPF allows for statistical multiplexing of one or more frame mode bearer connections over a single ISDN B-, D- or H-channel by use of LAPF and compatible HDLC procedures. In particular, LAPF is characterized by:

- close relationship with the peer-to-peer procedures of LAPD;
- symmetric procedural behavior with respect to the user-network interface, thus allowing also direct user-to-user interworking with the network side being passive (or only supporting the DL-CORE protocol);
- a core sublayer comprising the DL-CORE procedures, as given in Annex A;
- applicability on any ISDN channel, i.e. on B-, D- or H-channels;
- shared use of the D-channel, concurrently with LAPD (see Recommendation Q.921 [2]);
- use of data link connection identifiers (DLCIs) to uniquely identify frame mode virtual links being assigned to the bearer connections multiplexed on a B-, D- or H-channel;
- provision of a dedicated DLCI for layer management;
- use within a layered protocol suite which allows interworking between:
  - frame relaying and frame switching services;
  - frame relaying and X.25-based services;
  - frame switching and X.25-based services.

Network layer protocols which provide and support the N-Data-Transfer phase of the OSI connection oriented network service (CONS – See Recommendation X.213 [5]) may be conveyed by the service provided by this Recommendation. Two such network layer protocols are:

- the Data Transfer phase of Recommendation X.25 [6], and
- the protocol specified in Appendix IV.

DLCI assignment is performed using group signalling (as defined in Appendix II) or by subscription or prior agreement.

The concepts, terminology, overview description of data link functions and procedures and the relationship with other Recommendations are described in general terms in Recommendation Q.920 [7].

*Note 1* – As stated in Recommendation Q.920 [7], the term "data link layer" is used in the main text of this Recommendation. However, mainly in figures and tables the terms "layer 2" and "L2" are used as abbreviations. Furthermore, the term "layer 3" is used to indicate the layer above the data link layer.

*Note 2* – All references within this document to the "layer management entity" and/or "connection management entity" refer to those entities at the data link layer.

## 2 Frame structure for peer-to-peer communication

### 2.1 *General*

All data link layer peer-to-peer exchanges are in frames conforming to one of the formats shown in Figure 1/Q.921 [2].

### 2.2 *Flag sequence*

All frames shall start and end with the flag sequence consisting of one 0 bit followed by six contiguous 1 bits and one 0 bit. The flag preceding the address field is defined as the opening flag. The flag following the frame check sequence (FCS) field is defined as the closing flag. The closing flag may also serve as the opening flag of the next frame, in some applications. However, all receivers must be able to accommodate receipt of one or more consecutive flags. See ISDN user-network interfaces: layer 1 Recommendations I.430 [4] and I.431 [16] for applicability.

*Note* – It is recommended that flags be used as interframe fill on channels other than D-channels.

### 2.3 *Address field*

The address field shall consist of at least two octets. The format of the address field is defined in § 3.2.

### 2.4 *Control field*

The definition and use of the control field are indicated in Recommendation Q.921 [2].

### 2.5 *Information field*

The definition and use of the information field are indicated in Recommendation Q.921 [2]. The maximum number of octets in the information field is defined in § 5.9.3.

### 2.6 *Transparency*

The definition and use of transparency are indicated in Recommendation Q.921 [2].

### 2.7 *Frame check sequence (FCS)*

The definition and use of the FCS are indicated in Recommendation Q.921 [2].

### 2.8 *Format convention*

The definition of formats and numbering conventions are as in Recommendation Q.921 [2].

### 2.9 *Invalid frames*

An invalid frame is a frame which:

a) is not properly bounded by two flags;

b) has fewer than three octets between the address field (as defined in § 3.2) and the closing flag;

c) does not consist of an integral number of octets prior to "0" bit insertion or following "0" bit extraction;

d) contains a frame check sequence error;

e) contains a single octet address field; or

f) contains a DLCI which is not supported by the receiver.

Invalid frames shall be discarded without notification to the sender. No action is taken as the result of invalid frames.

### 2.10 *Frame aborts*

The definition of and the reaction to frame aborts is as in Recommendation Q.921 [2].

## 3 Elements of procedures and formats of fields for data link layer peer-to-peer communication

### 3.1 *General*

The elements of procedures define the commands and responses that are used for peer-to-peer communication using the data link layer connections.

Procedures are derived from these elements of procedures and are described in § 5.

### 3.2 *Address field format*

The address field format shown in Figure 1/Q.922 contains the address field extension bits, a command/response indication, 3 bits reserved for forward and backward explicit congestion notification and discard eligibility (used with frame relaying services per Annex A), a data link connection identifier (DLCI) field and a bit to indicate whether the final octet of a 3 or 4 octet "address field" is lower DLCI or DL-CORE control (see § 3.3.7) information. The minimum and default length of the address field is 2 octets and it may be extended to 3 or 4 octets to support a larger DLCI address range or to support optional DL-CORE control functions. The 3-octet and 4-octet address field formats may be supported at the user-network interface or at the network-network interface based on negotiation or bilateral agreement.

The support of address fields longer than two octets is an option chosen by bilateral agreement. This option includes distinctions for supporting the address field length varying on an interface basis or on a per channel basis.

### 3.3 *Address field variables*

#### 3.3.1 *Address field extension bit (EA)*

The address field range is extended by reserving the first transmitted bit of the address field octets to indicate the final octet of the address field. The presence, of a 0 in the first bit of an address field octet signals that another octet of the address field follows this one. The presence of a 1 in the first bit of an address field octet signals that it is the final octet of the address field. For example, the two octet address field has bit one of the first octet set to "0" and bit one of the second octet set to "1".

#### 3.3.2 *Command/response field bit (C/R)*

The C/R bit identifies a frame as either a command or a response. When the frame to be sent is a command frame, the C/R bit shall be set to 0. When the frame to be sent is a response frame, the C/R bit shall be set to 1.

#### 3.3.3 *Forward explicit congestion notification bit (FECN)*

This bit is reserved for use with frame relaying service, as described in Annex A and Appendix I.

Default address field format (2 octets)

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|
| Upper DLCI | | | | | | C/R | EA<br>0 |
| Lower DLCI | | | | FECN<br>(Note) | BECN<br>(Note) | DE<br>(Note) | EA<br>1 |

or

3 octets address field format

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|
| Upper DLCI | | | | | | C/R | EA<br>0 |
| DLCI | | | | FECN<br>(Note) | BECN<br>(Note) | DE<br>(Note) | EA<br>0 |
| Lower DLCI or<br>DL-CORE control | | | | | | D/C | EA<br>1 |

or

4 octets address field format

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|
| Upper DLCI | | | | | | C/R | EA<br>0 |
| DLCI | | | | FECN<br>(Note) | BECN<br>(Note) | DE<br>(Note) | EA<br>0 |
| DLCI | | | | | | | EA<br>0 |
| Lower DLCI or<br>DL-CORE control | | | | | | D/C | EA<br>1 |

EA Address field extension bit

C/R Command response bit

FECN Forward explicit congestion notification

BECN Backward explicit congestion notification

DLCI Data link connection identifier

DE Discard eligibility indicator

D/C DLCI or DL-CORE control indicator

*Note* — See Annex A and Appendix I for the use of these 3 bits whiche are reserved for congestion notification signalling with frame relaying.

FIGURE 1/Q.922

**Address field formats**

### 3.3.4 *Backward explicit congestion notification bit (BECN)*

This bit is reserved for use with frame relaying service, as described in Annex A and Appendix I.

### 3.3.5 *Discard eligibility indicator (DE)*

This bit is reserved for use with frame relaying service, as described in Annex A and Appepndix I.

### 3.3.6 *Data link connection identifier (DLCI)*

The DLCI identifies a virtual connection on a bearer channel (i.e. D, B or H) at a user to network or network to network interface. Consequently, a DLCI specifies a data link layer entity to/from which information is delivered/received and which is to be carried in frames by data link layer entities. The DLCI field may be either unstructured or structured. In the former case, the least significant bit is determined as follows:

| Address field size | D/C = 0 | D/C = 1 |
|---|---|---|
| 2 octets | (Note) | (Note) |
| 3 octets | bit 3 of octet 3 | bit 5 of octet 2 |
| 4 octets | bit 3 of octet 4 | bit 2 of octet 3 |

*Note* – Not applicable; least significant DLCI bit is bit 5 of octet 2.

A structure to the DLCI field may be established by the network at the user to network interface or at a network to network interface subject to negotiation or bilateral agreement.

For notation purposes, the 6 most significant bits (bits 8 to 3) in the first octet of the address field (which correspond to the SAPI field in Recommendation Q.921 [2]) are referred to as the upper DLCI.

Table 1/Q.922 shows the ranges of DLCI values which apply for specific functions to ensure compatibility with operation on a D-channel, which also may use the Q.921 [2] protocol. A two octet address field format for this Recommendation is assumed when used on a D-channel. For further study is whether 3 or 4 octet address field formats may be used on a D-channel.

### 3.3.7 *DLCI/DL-CORE control indicator (D/C)*

The D/C indicates whether the remaining six usable bits of that octet are to be interpreted as the lower DLCI bits or as DL-CORE control bits. The bit is set to 0 to indicate that the octet contains DLCI information. This bit is set to 1 to indicate that the octet contains DL-CORE control information. This indicator is limited to use in the last octet of the three or four octet type “address field”. The use of this indication for DL-CORE control is reserved as there have not been any additional control functions defined which need to be carried in the “address field”; this indicator has been added to provide for possible future expansion of the protocol.

*Note* – The optional DL-CORE control field is part of the address field and therefore must not be confused with the control field of an HDLC frame as defined in Figure 1/Q.921.

## 3.4 *Control field formats*

The control field identifies the type of frame, which will be either a command or response. The control will contain sequence numbers where applicable.

Three types of control field formats are specified: numbered information transfer (I format), supervisory fractions (S format), and unnumbered information transfers and control functions (U format). The control field formats are shown in Table 2/Q.922.

TABLE 1/Q.922

**Use of DLCIs**

| 10 bits DLCIs (Note 1) | |
|---|---|
| DLCI range | Function |
| 0 (Note 2) | In channel signalling, if required |
| 1-15 | Reserved |
| 16-511 | Network option: on non-D-channels, available for support of user information |
| 512-991 | Logical link identification for support of user information (Note 6) |
| 992-1007 | Layer 2 management of frame mode bearer service |
| 1008-1022 | Reserved |
| 1023 (Note 2) | In channel layer 2 management, if required |
| **16 bits DLCIs (Note 3)** | |
| DLCI range | Function |
| 0 (Note 2) | In channel signalling, if required |
| 1-1023 | Reserved |
| 1024-32 767 | Network option: on non-D-channels, available for support of user information |
| 32 768-63 487 | Logical link identification for support of user information (Note 6) |
| 63 488-64 511 | Layer 2 management of frame mode bearer service |
| 64 512-65 534 | Reserved |
| 65 535 (Note 2) | In channel layer 2 management, if required |
| **17 bits DLCIs (Note 4)** | |
| DLCI range | Function |
| 0 (Note 2) | In channel signalling, if required |
| 1-2047 | Reserved |
| 2048-65 535 | Network option: on non-D-channels, available for support of user information |
| 65 536-126 975 | Logical link identification for support of user information (Note 6) |
| 126 976-129 023 | Layer 2 management of frame mode bearer service |
| 129 024-131 070 | Reserved |
| 131 071 (Note 2) | In channel layer 2 management, if required |
| **23 bits DLCIs (Note 5)** | |
| DLCI range | Function |
| 0 (Note 2) | In channel signalling, if required |
| 1-131 071 | Reserved |
| 131 072-4 194 303 | Network option: on non-D-channels, available for support of user information |

*Note 1* — These DLCIs apply when a 2 octet address field is used or when a 3 octet address field is used with D/C = 1.

*Note 2* — Only available within non-D-channel.

*Note 3* — These DLCIs apply for non-D-channels when a 3 octet address field is used with D/C = 0.

*Note 4* — These DLCIs apply for non-D-channels when a 4 octet address field is used with D/C = 1.

*Note 5* — These DLCIs apply for non-D-channels when a 4 octet address field is used with D/C = 0.

*Note 6* — The use of semi-permanent frame mode connections may reduce the number of DLCIs available from this range.

TABLE 2/Q.922

**Control field formats**

| Control field bits (modulo 128) | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
|---|---|---|---|---|---|---|---|---|---|
| I format | N(S) | | | | | | | 0 | Octet 4 (Note) |
| | N(R) | | | | | | | P/F | Octet 5 |
| S format | X | X | X | X | Su | Su | 0 | 1 | Octet 4 |
| | N(R) | | | | | | | P/F | Octet 5 |
| U format | M | M | M | P/F | M | M | 1 | 1 | Octet 4 |

N(S) Transmitter send sequence number

N(R) Transmitter receive sequence number

P/F Poll bit when used as a command, final bit when used as a response

X Reserved and set to 0

Su Supervisory function bit

M Modifier function bit

*Note* — The identification of these octets is consistent whith a 2 octet address field.
The values will be increased by 1 for a 3 octet address field and by 2 for a 4 octet address field.

### 3.4.1 *Information transfer (I) format*

The I format shall be used to perform an information transfer between layer 3 entities. The functions of N(S), N(R) and P/F (defined in § 3.5 of Recommendation Q.921 [2]) are independent; that is, each I frame has a N(S) sequence number, and a N(R) sequence number which may or may not acknowledge additional I frames received by the data link layer entity, and a P/F bit that may be set to 0 or 1.

The use of N(S), N(R) and P/F is defined in § 5 of Recommendation Q.921 [2].

*Note* – This I format differs from that of LAPD because LAPF allows the use of the F-bit.

### 3.4.2 *Supervisory (S) format*

The use of the S format is the same as that specified in Recommendation Q.921 [2].

### 3.4.3 *Unnumbered (U) format*

The use of the U format is the same as that specified in Recommendation Q.921 [2].

## 3.5 *Control field parameters and associated state variables*

The various parameters associated with the control field formats are described in Recommendation Q.921 [2].

### 3.6 *Frame types*

#### 3.6.1 *Commands and responses*

The following commands and responses are used by either the user or the network data link layer entities and are represented in Table 3/Q.922. Each data link connection shall support the full set of commands and responses for each application implemented. The frame types associated with each of the two applications are identified in Table 3/Q.922.

Frame types associated with an application not implemented shall be discarded and no action shall be taken as a result of that frame.

For purposes of the LAPF procedures in each application, those encodings not identified in Table 3/Q.922 are identified as undefined command and response fields. The actions to be taken are specified in § 5.8.5.

The commands and responses in Table 3/Q.922 are defined in §§ 3.6.2 to 3.6.12.

TABLE 3/Q.922

**Commands and responses — modulo 128**

| Application | Format | Commands | Responses | Encoding 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unacknowledged and multiple frame acknowledged information transfer | I | I | I | N(S) | | | | | | | 0 |
| | | | | N(R) | | | | | | | P/F |
| | S | RR | RR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | | | | N(R) | | | | | | | P/F |
| | | RNR | RNR | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | | | | N(R) | | | | | | | P/F |
| | | REJ | REJ | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | | | | N(R) | | | | | | | P/F |
| | U | SABME | | 0 | 1 | 1 | P | 1 | 1 | 1 | 1 |
| | | | DM | 0 | 0 | 0 | F | 1 | 1 | 1 | 1 |
| | | UI | | 0 | 0 | 0 | P | 0 | 0 | 1 | 1 |
| | | DISC | | 0 | 1 | 0 | P | 0 | 0 | 1 | 1 |
| | | | UA | 0 | 1 | 1 | F | 0 | 0 | 1 | 1 |
| | | | FRMR | 1 | 0 | 0 | F | 0 | 1 | 1 | 1 |
| Connection management (Note 1) | U | XID | XID | 1 | 0 | 1 | P/F | 1 | 1 | 1 | 1 |

*Note 1* — Congestion management is included in this row of the table.

*Note 2* — Use of the SREJ frame is for further study.

3.6.2 *Information command/response*

The function of the information (I) frame is to transfer, across a data link connection, sequentially numbered frames containing information fields provided by layer 3. The I command is used in the multiple frame operation on a point-to-point data link. The I response may be received by the data link layer entity in the multiple frame operation on a point-to-point data link.

*Note* – This differs from LAPD by adding information response frames.

3.6.3 *Set asynchronous balanced mode extended (SABME) command*

The SABME unnumbered command is defined in Recommendation Q.921 [2].

3.6.4 *Disconnection (DISC) command*

The DISC unnumbered command is defined in Recommendation Q.921 [2].

3.6.5 *Unnumbered information (UI) command*

The UI unnumbered command is defined in Recommendation Q.921 [2].

3.6.6 *Receive ready (RR) command/response*

The RR supervisory frame is defined in Recommendation Q.921 [2].

3.6.7 *Reject (REJ) command/response*

The REJ supervisory frame is defined in Recommendation Q.921 [2].

3.6.8 *Receive not ready (RNR) command/response*

The RNR supervisory frame is defined in Recommendation Q.921 [2].

3.6.9 *Unnumbered acknowledgement (UA) response*

The UA unnumbered response is defined in Recommendation Q.921 [2].

3.6.10 *Disconnected mode (DM) response*

The DM unnumbered response is defined in Recommendation Q.921 [2].

3.6.11 *Frame reject (FRMR) response*

The FRMR unnumbered response may be sent or received by a data link layer entity as a report of an error condition not recoverable by retransmission of the identical frame, i.e., at least one of the following error conditions resulting from the receipt of a valid frame:

a) the receipt of a command or response control field that is undefined or not implemented;

b) the receipt of a supervisory frame or unnumbered frame with incorrect length;

c) the receipt of an invalid N(R); or

d) the receipt of a frame with an I field that exceeds the maximum established length.

An undefined control field is any of the control field encodings that are not identified in Table 3/Q.922.

A valid N(R) field is one that is in the range $V(A) \leq N(R) \leq V(S)$, where V(A) is the acknowledge state variable and V(S) is the send state variable (see §§ 3.5.2.2 and 3.5.2.3 of Recommendation Q.921 [2]).

The FRMR response frame information field is defined in Recommendation Q.921 [2].

3.6.12 *Exchange identification (XID) command/response*

The XID frame is defined in Recommendation Q.921 [2] for the connection management application. For the congestion management application, the XID frame is defined in Annex A.

# 4 Elements for layer-to-layer communication

## 4.1 *General*

Communications between layers and, for this Recommendation, between the data link layer and the layer management are accomplished by means of primitives.

Primitives represent, in an abstract way, the logical exchange of information and control between the data link and adjacent layers. They do not specify or constrain implementations.

An architectural model showing the relationships among the layers and sublayers of both the C-plane and the U-plane, together with their layer management entities and system management, is given in Figure 2/Q.922. In this model, a key component is the synchronization and convergence function (SCF) within the network layers of both the C-plane and the U-plane. This SCF coordinates connection establishment and release between the C-plane and the U-plane. The SCF and the U-plane layer 3 functions are outside the scope of this Recommendation.

An overview model, illustrating the flow of messages and service primitives, is provided in Figures 3/Q.922 through 6/Q.922. These figures provide more detailed flow information for the model illustrated in Figure 2/Q.922. For simplification of representation, the C-plane layer 3 functional block has been merged with the U-plane layer 3 functional block and with the SCF. Only the DL-SAP in the U-plane is shown; the DL-SAP in the C-plane in support of signalling is not illustrated.

Primitives consist of commands and their respective responses associated with the services requested of a lower or an upper layer. The general syntax of a primitive is:

XX – Generic name – Type: Parameters

where XX designates the interface across which t he primitive flows. For this Recommendation, XX is:

– DL-CORE for communications between the DL-CORE user and the DL-CORE (discribed in § A.4);

– DL for communications between layer 3 and the data link layer;

– PH for communications between the data link layer and the physical layer;

– MC for communication between the DL-CORE and layer 2 management (described in § A.4);

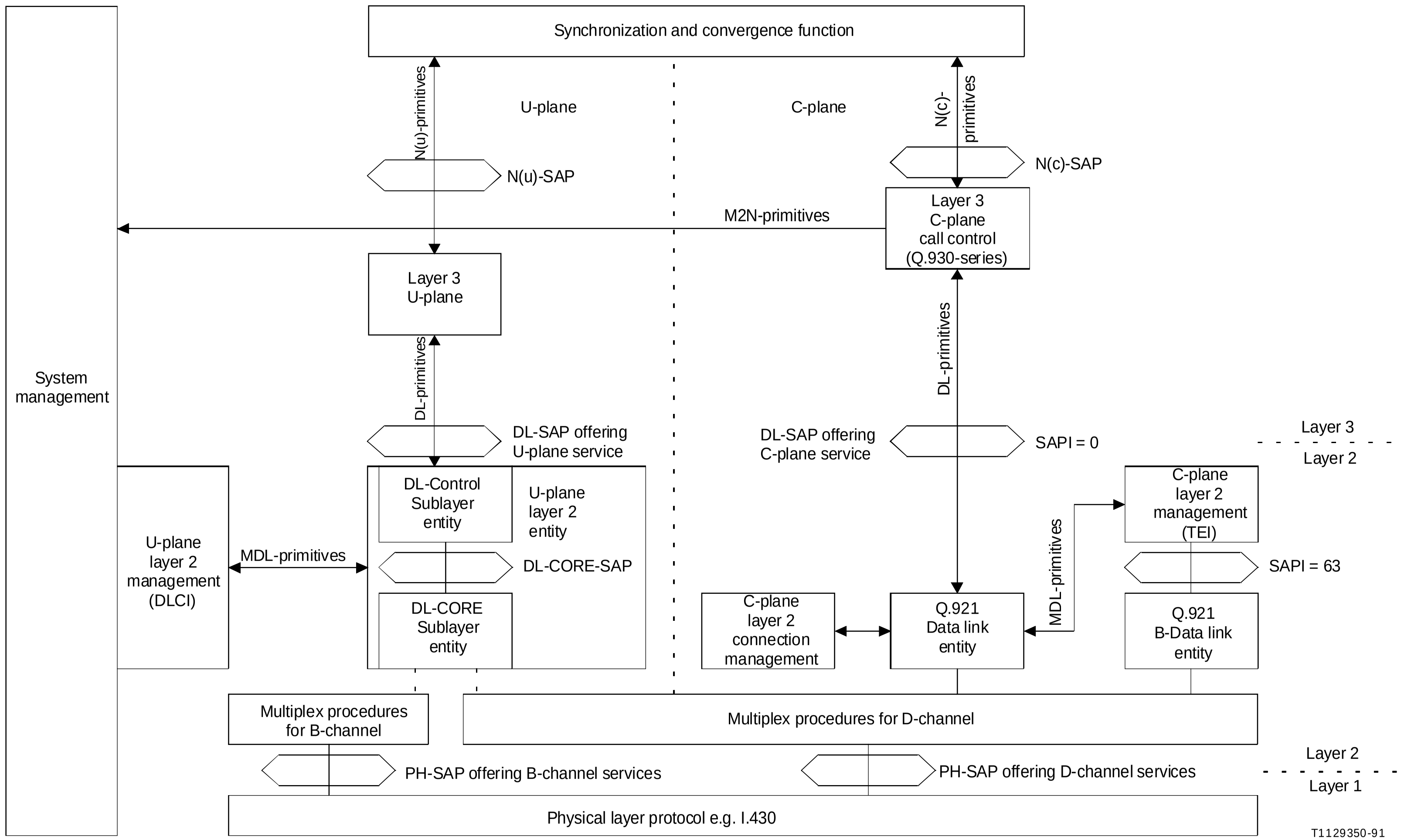
– MDL for communications between the layer 2 management and the data link layer; or

– M2N for communications between the layer 3 and layer 2 management entities.

A general representation of primitive interactions with frame types within the U-plane and layer 3 messages within the C-plane is described in Figures 3/Q.922 through 6/Q.922.

The U-plane layer 2 functional block supports the layer 2 protocol procedures in accordance with this Recommendation. Layer 2 U-plane services are provided at DL-SAP and may be invoked by the service user by means of DL-primitives.

The layer 3 functional block includes the functionality for call control within the C-plane (Q.933 [3] call control procedures), the layer 3 U-pIane functionality and the functions to perform coordination between C- and U-plane layer 3 entities.




*Note* – The DL-CONTROL protocol may be a Q.922 protocol procedure, another CCITT specified protocol, or any protocol between endsystems which, as a DL-CORE service user, is compatible with the DL-CORE sublayer services.

FIGURE 2/Q.922

**Functional model overview representation**

The U-plane layer management functional blocks coordinate connection establishment and release between the service user's call control and that of the service provider. It passes the DLCI to be used to identify the U-plane layer 2 connection from layer 3 to layer 2 by means of the primitives M2N-ASSIGN request and MDL-ASSIGN request, and establishes the association between DL-CEI and DLCI. When a connection is to be released, it removes the DLCI and releases the association between DL-CEI and DLCI.

Figures 3/Q.922 and 4/Q.922 depict connection establishment. All the U-plane layer 2 protocol entities are in the *TEI assigned* state. The signal flow starts at the calling side (Figure 3/Q.922) with the SETUP message and ends with the DL-ESTABLISH confirm primitive. The SETUP message at the calling side results in a SETUP message at the called side which is the start for the called side signalling flow in Figure 4/Q.922.

Figure 5/Q.922 depicts the signal flow for connection release. The same flow applies to the user-network interface where connection release is initiated (by the user side in the figure) and to the user-network interface where connection release is indicated (by the network side in the figure). To release the connection in a coordinated manner, the U-plane layer 2 connection is released first, followed by a call release within the C-plane.

Figure 6/Q.922 depicts the various information transfer capabilities provided to the U-plane layer 2 service users.

### 4.1.1 *Generic names*

The generic name specifies the activity that should be performed. A summary of the primitives supported in this Recommendation is given in Table 4/Q.922. Note that not all primitives have associated parameters.

#### 4.1.1.1 *DL-ESTABLISH*

The DL-ESTABLISH primitives are defined in Recommendation Q.921 [2].

#### 4.1.1.2 *DL-RELEASE*

The DL-RELEASE primitives are defined in Recommendation Q.921 [2].

#### 4.1.1.3 *DL-DATA*

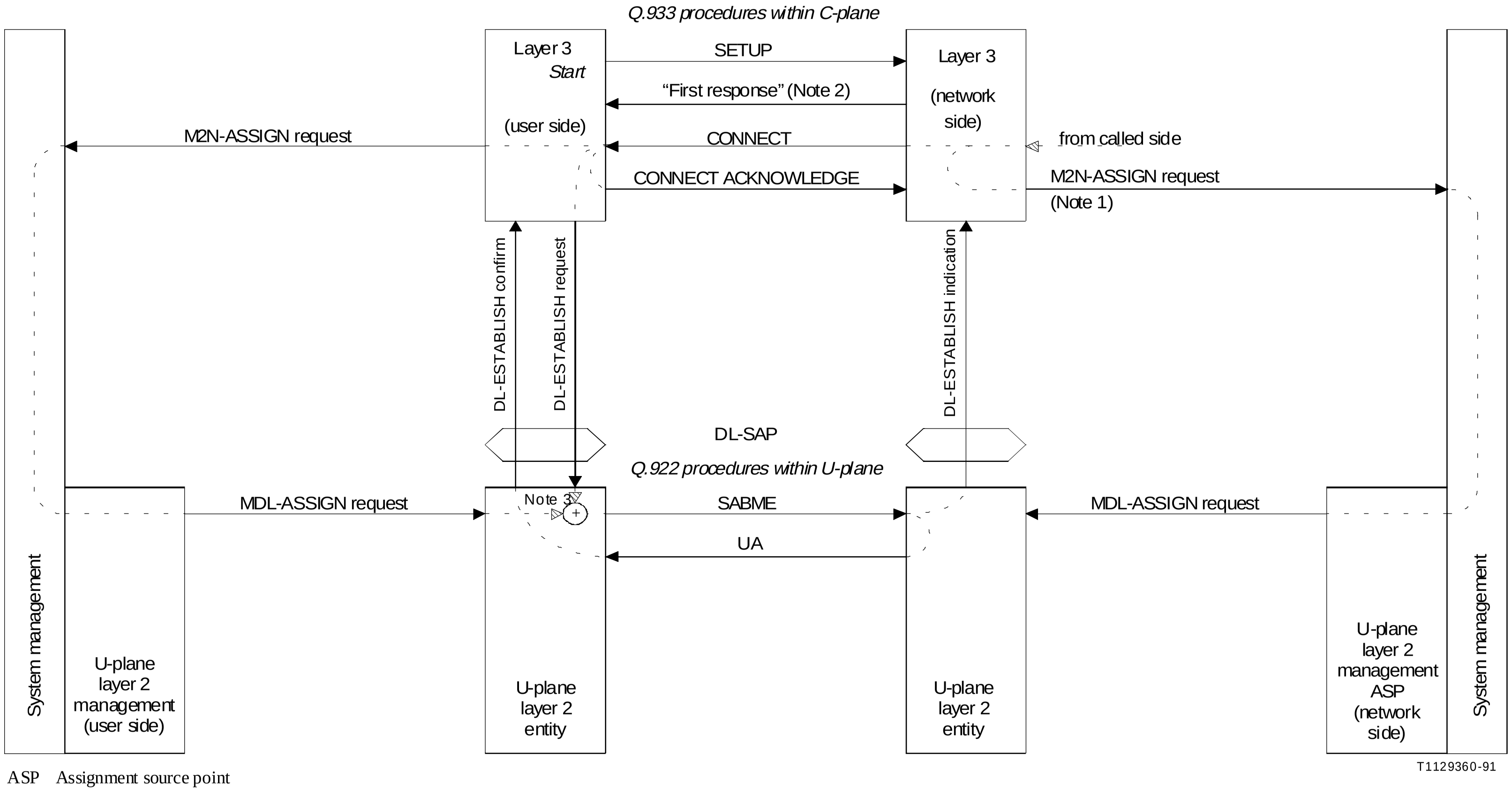
The DL-DATA primitives are defined in Recommendation Q.921 [2].

#### 4.1.1.4 *DL-UNIT-DATA*

The DL-UNIT-DATA primitives are defined in Recommendation Q.921 [2].

#### 4.1.1.5 *MDL-ASSIGN*

The MDL-ASSIGN request primitive is used by the layer management entity to request that the data link layer associate the layer 2 address value contained within the message unit of the primitive with the specified data link connection endpoint identifier (DL-CEI) and with the underlying physical connection.




ASP Assignment source point

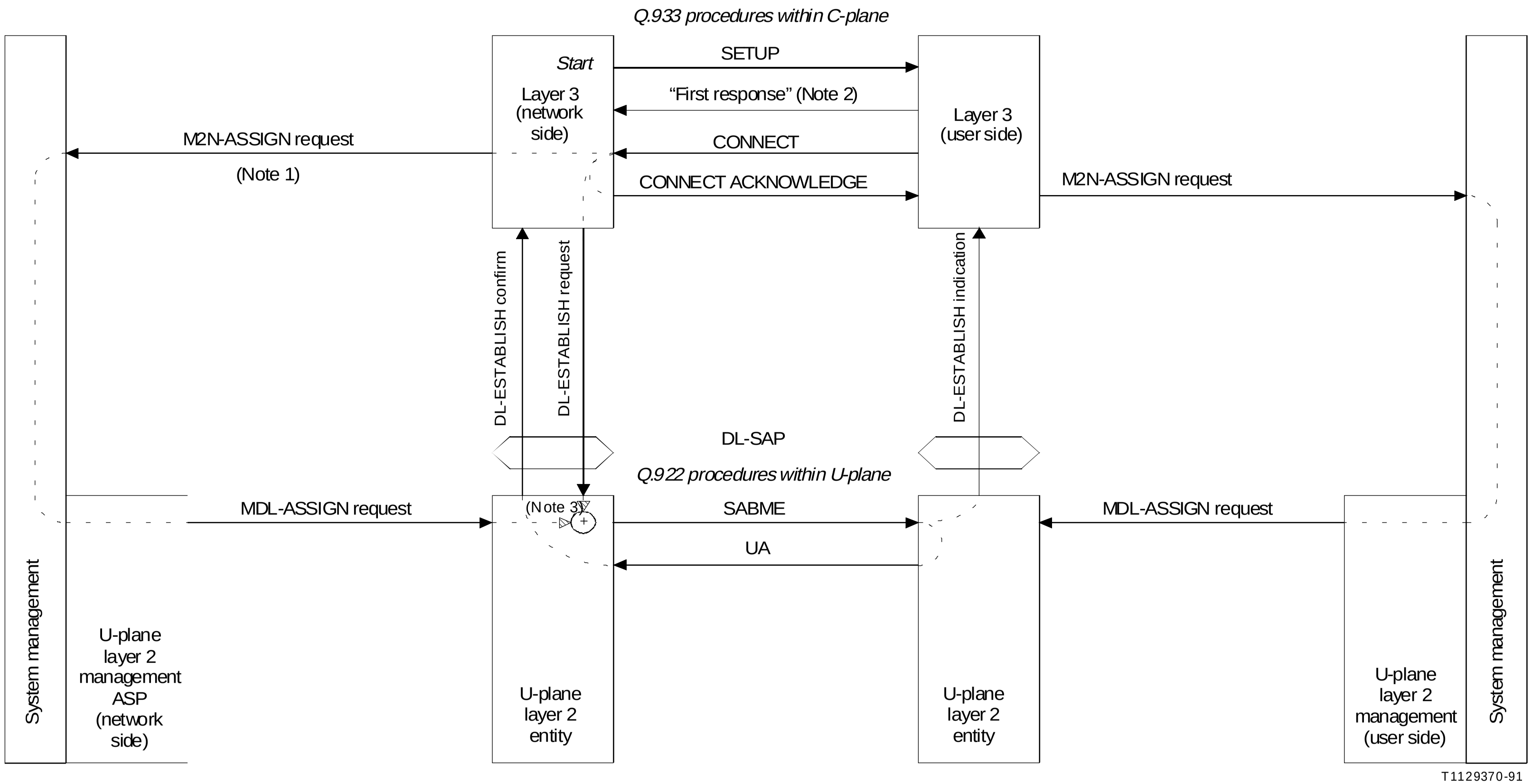
*Note 1* – See Figure 4/Q.922.

*Note 2* – The reserved DLCI is indicated in the first response to the SETUP message, e.g. CALL PROCEEDING.

*Note 3* – This reflects the case in which MDL-ASSIGN request is first; otherwise, the U-plane layer 2 entity would issue an MDL-ASSIGN indication to acquire a DLCI.

FIGURE 3/Q.922

**A representation of the relationship of primitives with frames and messages for connection establishment (calling side)**




ASP Assignment source point

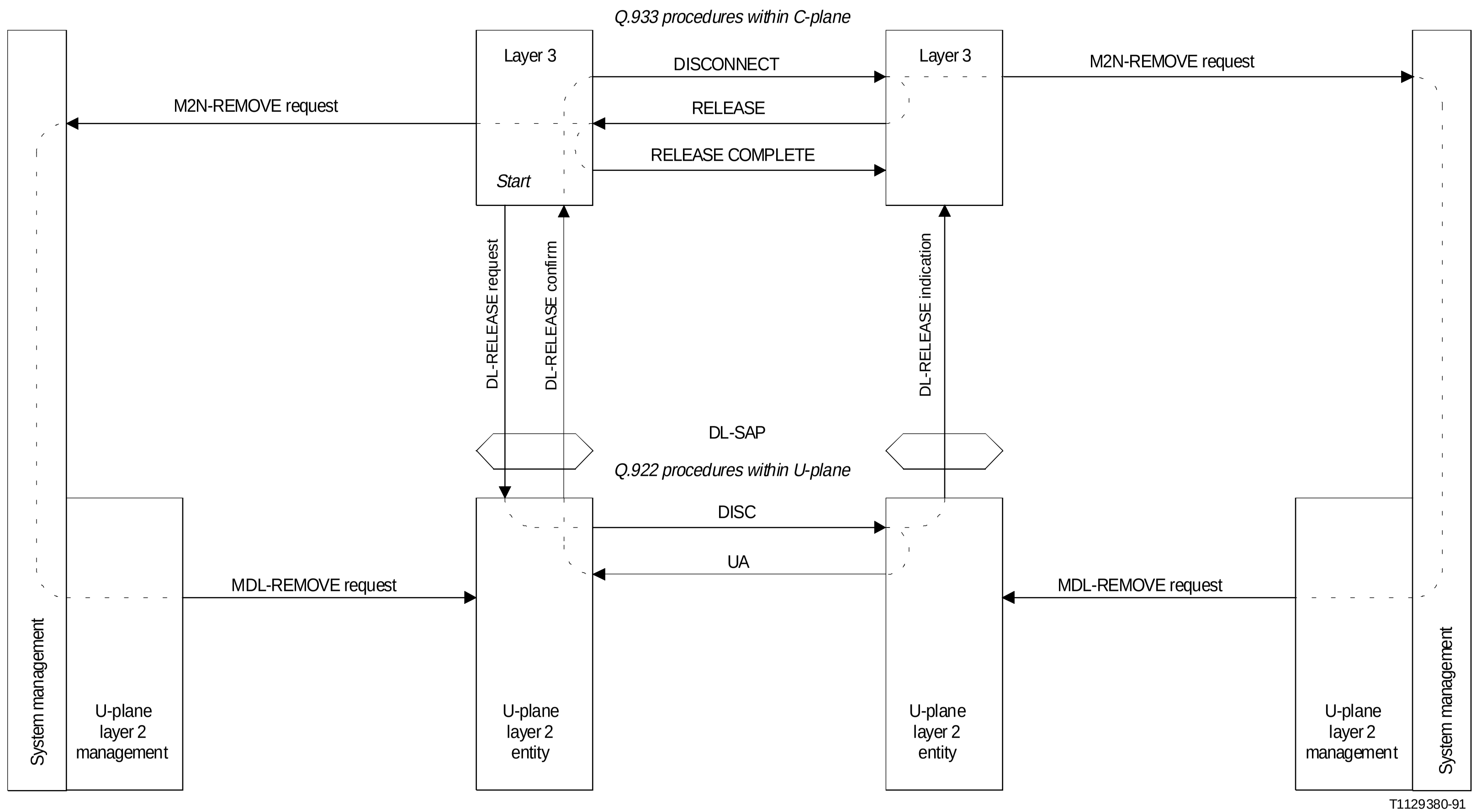
*Note 1* – Initialization procedures to establish a range of DLCIs for assignment are outside the scope of this model. The layer 3 network side acquired a range of DLCI codepoints so as to establish U-plane layer 2 connections.

*Note 2* – See Figure 3/Q.922.

*Note 3* – This reflects the case in which MDL-ASSIGN request is first; otherwise, the U-plane layer 2 entity would issue an MDL-ASSIGN indication to acquire a DLCI.

FIGURE 4/Q.922

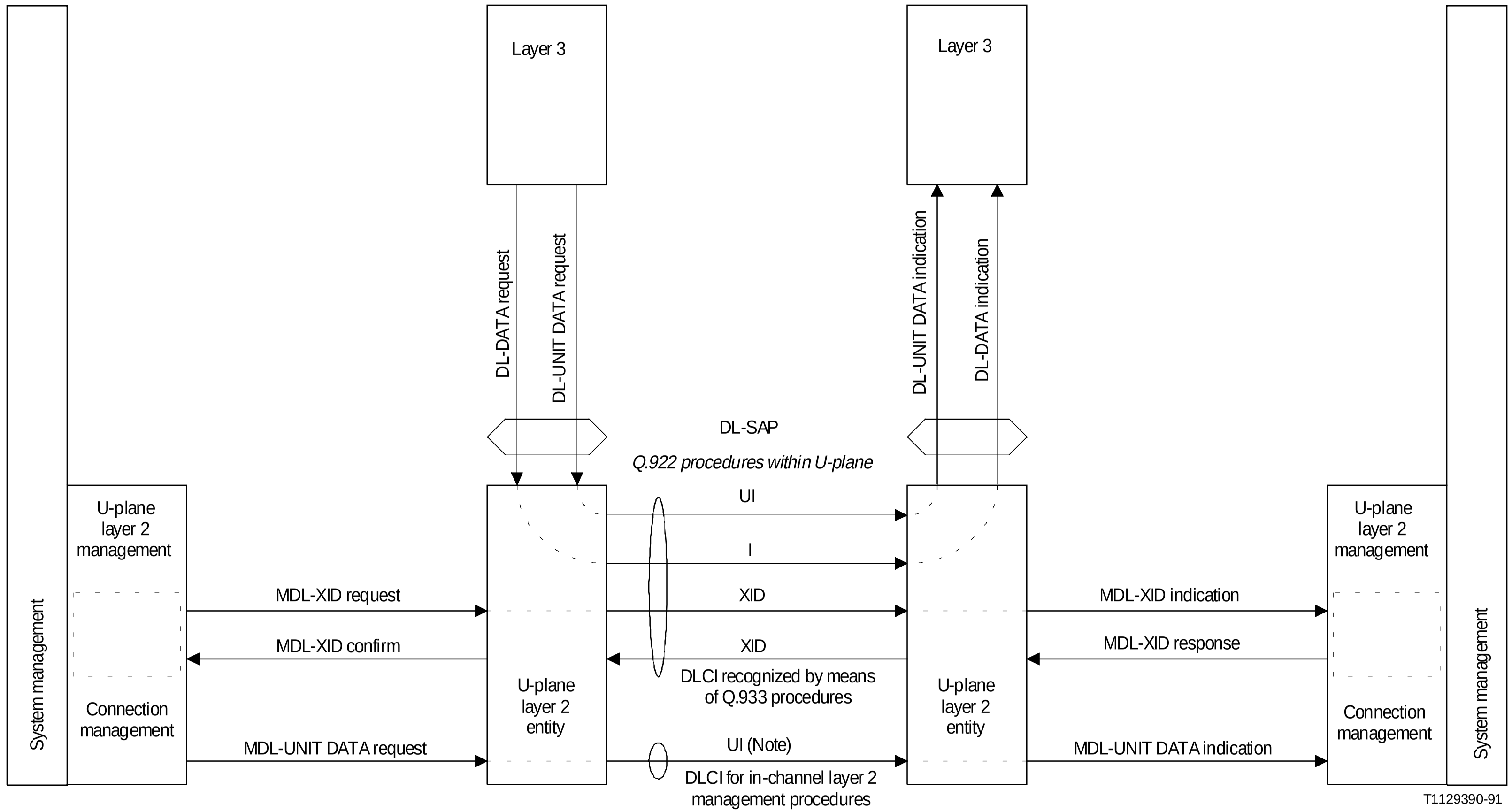
**A representation of the relationship of primitives with frames and messages for connection establishment (called side)**




*Note* – The left side could be the network side and the right side could be the user side, or vice versa, depending upon whether the network or the user side initiates connection release.

FIGURE 5/Q.922

**A representation of the relationship of primitives with frames and messages for connection release**




*Note* – Only on the link identified by the preassigned DLCI for in-channel management.

FIGURE 6/Q.922

**A representation of the relationship of primitives with frames for data transfer**

TABLE 4/Q.922

**Primitive types**

| Generic name | Type | | | | Parameter | | Message unit contents |
|---|---|---|---|---|---|---|---|
| | Re-quest | Indi-cation | Response | Confirmation | Priority indicator | Message unit | |
| Layer 3 — Layer 2 management | | | | | | | |
| M2N-ASSIGN | X | — | — | — | — | X | DL-CEI, DLCI (Note 1) |
| M2N-REMOVE | X | — | — | — | — | X | DLCI |
| Layer 3 — Layer 2 | | | | | | | |
| DL-ESTABLISH | X | X | (Note 2) | X | — | — | |
| DL-RELEASE | X | X | — | X (Note 3) | — | — | |
| DL-DATA | X | X | — | — | — | X | Layer 3 peer-to-peer message |
| DL-UNIT DATA | X | X | — | — | — | X | Layer 3 peer-to-peer message |
| Layer 2 — Layer 2 management | | | | | | | |
| MDL-ASSIGN | X | X | — | — | — | X | DLCI, DL-CEI |
| MDL-REMOVE | X | — | — | — | — | X | DLCI |
| MDL-ERROR | — | X | X | — | — | X | Reason for error (see Appendix V) |
| MDL-UNIT DATA | X | X | — | — | — | X | Management peer-to-peer message |
| MDL-XID | X | X | X | X | — | X | Connection management and congestion management information |
| Layer 2 — Layer 1 | | | | | | | |
| PH-DATA | X | X | — | — | X (Note 4) | X | Data link layer peer-to-peer message |
| PH-ACTIVATE | X | X | — | — | — | — | |
| PH-DEACTIVATE | — | X | — | — | — | — | |

*Note 1* — Optional parameters; if missing, default values are used or procedures of Appendix III are used.

*Note 2* — The DL-ESTABLISH response primitive is present in Recommendation X.212 [8] but not in this Recommendation. Its absence from this Recommendation removes the need to add an additional state "Waiting for response".

*Note 3* — The DL-RELEASE confirm primitive is present in this Recommendation but not in Recommendation X.212 [8]. It is used in this Recommendation to show the synchronization of the activities of layers 2 and 3.

*Note 4* — A priority indicator for layer 1 is not present in Recommendation X.211 [9] and is used only for the basic rate interface D-channel. Recommendation X.211 [9] does not consider priority as a layer 1 quality of service parameter.

*Note* – Additional, optional parameters may be included. These parameters may have originated from layer 3, from default values or through negotiation procedures according to Appendix III.

The MDL-ASSIGN indication primitive is used by the data link layer to indicate to the layer management entity the need for a layer 2 address value to be associated with the DL-CEI specified in the primitive message unit.

#### 4.1.1.6 *MDL-REMOVE*

The MDL-REMOVE primitives are used by the layer management entity to request that the data layer remove the association of the specified layer 2 address value with its associated DL-CEI. The layer 2 address is specified by the MDL-REMOVE primitive message unit.

#### 4.1.1.7 *MDL-ERROR*

The MDL-ERROR primitives are used to indicate to the connection management entity that an error has occurred, associated with a previous management function request or detected as a result of communication with the data link layer peer entity. The layer management entity may respond with an MDL-ERROR primitive if the layer management entity can not obtain a layer 2 address value.

#### 4.1.1.8 *MDL-UNIT-DATA*

The use of the MDL-UNIT-DATA primitives is defined in Recommendation Q.921 [2].

#### 4.1.1.9 *MDL-XID*

The MDL-XID primitives are defined in Recommendation Q.921 [2] for the connection management application. For the congestion management application, the MDL-XID response primitive is used to convey the congestion signalling information associated with the consolidated link layer management (CLLM).

#### 4.1.1.10 *M2N-ASSIGN*

The M2N-ASSIGN request primitive is used by the C-plane layer 3 entity to request that the layer 2 management entity associate a DLCI with a data link connection endpoint identifier (DL-CEI), where both identifiers are specified in the message unit. Additional, optional parameters (e.g. physical channel, T200, or window size) may be included in the message unit. The layer 2 management entity is prepared, thus, to receive an MDL-ASSIGN indication primitive from the layer 2 entity in accordance with § 4.1.1.5.

#### 4.1.1.11 *M2N-REMOVE*

The M2N-REMOVE request primitive is used by the C-plane layer 3 entity to request that the layer management entity remove the association between the specified DLCI and its associated DL-CEI. The layer 2 management entity then uses the MDL-REMOVE request primitive in accordance with § 4.1.1.6.

#### 4.1.1.12 *PH-DATA*

The PH-DATA primitives are defined in Recommendation Q.921 [2].

#### 4.1.1.13 *PH-ACTIVATE*

The PH-ACTIVATE primitives are defined in Recommendation Q.921 [2].

4.1.1.14 *PH-DEACTIVATE*

The PH-DEACTIVATE primitives are defined in Recommendation Q.921 [2].

4.1.2 *Primitive types*

The primitive types are defined in Recommendation Q.921 [2].

4.1.3 *Parameter definition*

4.1.3.1 *Priority indicator*

The priority indicator for layer 1 is defined in Recommendation I.430 [4] and is used only for basic rate interface D-channeI application.

Since several SAPs may exist on either side of the user-network interface, protocol message units sent by one SAP may contend with those of other service access points for the physical resources available for message transfer. The priority indicator is used to determine which message unit will have greater priority when contention exist. The priority indicator is only needed at the user side for distinguishing message units sent by the SAP with an upper DLCI value of 0 from all other message units.

*Note* – This parameter is not the same as the "Transfer Priority" parameter defined in Recommendation I.370 [10] and discussed in Annex A.

4.1.3.2 *Message unit*

The message unit is defined in Recommendation Q.921 [2].

4.2 *Primitive procedures*

Primitive procedures are defined in Recommendation Q.921 [2]; broadcast links are not used in this Recommendation.

## 5 Definition of the peer-to-peer procedures of the data link layer

The procedures for use by the data line layer are specified in the following paragraphs.

The elements of procedure (frame types) which apply are:

a) for unacknowledged information transfer (see § 5.2):
   - UI-command

b) for mutiple frame acknowledged information transfer (see §§ 5.5 to 5.8):
   - SABME-command
   - UA-response
   - DM-response
   - DISC-command
   - RR-command/response
   - RNR-command/response
   - REJ-command/response
   - I-command/response
   - FRMR-response

c) for connection management entity information transfer (see Appendix III):
   - XID-command/response

d) for CLLM congestion management information transfer (see § A.7):

– XID-response

e) for further study:

– TEST-command/response

– SREJ-command/response.

5.1 *Procedure for the PIF bit*

The use of the P/F bit is as defined in Recommendation Q.921 [2].

5.2 *Procedures for unacknowledged information transfer*

5.2.1 *General*

The procedures which apply to the transmission of information in unacknowledged operation are defined below.

No data link layer error recovery procedures are applicable to unacknowledged operation.

5.2.2 *Transmission of unacknowledged information*

Unacknowledged information is passed to the data link layer entity by the data link service user (DL service user) or management entities using primitives DL-UNIT DATA request or MDL-UNIT DATA request, respectively. The DL service user or management message unit shall be transmitted in a UI command frame using an appropriate DLCI value.

The P bit shall be set to 0.

In case of persistent layer 1 deactivation, the data link layer will be informed by an appropriate indication. Upon receipt of this indication, all UI transmission queues shall be discarded.

5.2.3 *Receipt of unacknowledged information*

On receipt of a UI command frame with a DLCI that is supported by the receiver, the contents of the information field shall be passed to the DL service user or management entity using the data link layer to DL service user primitive DL-UNIT DATA indication or the data link layer to management primitive MDL-UNIT DATA indication, respectively. If the DLCI is not supported by the receiver, the UI command frame shall be discarded.

5.3 *DLCI management*

When using a frame mode bearer service, the DLCI value either will be negotiated in the C-plane when using Q.933 [3] call establishment procedures or will be assigned by means of administration procedures when using permanent virtual circuits at subscription time.

Once the DLCI value is available for assignment, an MDL-ASSIGN request primitive is sent from layer management to the U-plane data link layer entity. It contains both the DLCI value to be assigned and the associated DL-CEI.

*Note* – DLCI management when using a circuit mode bearer service is for further study.

5.4 *Automatic negotiation of data link layer parameters*

Two methods of negotiation are available:

i) for negotiation as part of the connection establishment procedure (e.g. using Recommendation Q.933); and

ii) for negotiation within the data link connection using XID frames as described in Appendix III.

The use of defaults for parameter values is allowed. The default values to be used are specified in § 5.9.

5.5 *Procedures for establishment and release of multiple frame operation*

5.5.1 *Establishment of multiple frame operation*

5.5.1.1 *General*

General discussion of establishment of multiple frame operation is described in Recommendation Q.921 [2].

5.5.1.2 *Establishment procedures*

Details of establishment are given in Recommendation Q.921 [2].

Note – The corresponding text in Recommendation Q.921 [2] uses state *TEI assigned*. For historical reasons, and for compatibility of terminology, the state named *TEI assigned* is retained. This state is defined as the state where a DLCI has been assigned to a logical links as long as the link has not been established.

5.5.1.3 *Procedure on expiry of timer T200*

Procedures for action upon expiry of timer T200 are indicated in Recommendation Q.921 [2].

5.5.2 *Information transfer*

Procedures for information transfer are defined in Recommendation Q.921 [2].

5.5.3 *Termination of multiple frame operation*

Discussion of and procedures for termination of multiple frame operation are in Recommendation Q.921 [2].

5.5.4 *TEI assigned state*

Discussion and procedures for operation while in the *TEI assigned* state (see Note in § 5.5.1.2), are defined in Recommendation Q.921 [2].

5.5.5 *Collision of unnumbered commands and responses*

Collision of unnumbered commands and responses is handled according to Recommendation Q.921 [2].

5.5.6 *Unsolicited DM response and SABME or DISC command*

Unsolicited DM response and SABME or DISC commands are handled according to Recommendation Q.921 [2].

## 5.6 *Procedures for information transfer in multiple frame operation*

The procedures which apply to the transmission of I frames are defined below.

*Note* – the term “transmission of an I frame” refers to the delivery of an I frame by the data link layer to the physical layer.

### 5.6.1 *Transmission I frames*

The transmission of I frame is as defined in Recommendation Q.921 [2].

### 5.6.2 *Receiving I frames*

During multiple frame acknowledged information transfer operation, I frames sent as either commands or responses, shall be received.

Independent of the timer-recovery state, when a data link layer entity is not in an own-receiver-busy condition and receives a valid I frame whose N(S) is equal to the current V(R), the data link layer entity shall:

- pass the information field of this frame to the layer 3 entity using the DL-DATA indication primitive; and
- increment by 1 its V(R) and act as indicated below for the appropriate condition.

#### 5.6.2.1 *P-bit set to 1*

Processing of an I frame with a P-bit set to 1 is defined in Recommendation Q.921 [2].

#### 5.6.2.2 *P-bit set to 0*

Processing of an I frame with a P-bit set to 0 is defined in Recommendation Q.921 [2].

#### 5.6.2.3 *F-bit set to 0*

Independent of the timer-recovery state, when a data link layer entity receives a valid I frame response with F-bit set to 0, it shall treat the frame as a valid I frame command with P-bit set to 0 and follow procedures of § 5.6.2.2 of Recommendation Q.921 [2].

#### 5.6.2.4 *F bit set to 1*

Upon receipt of an I frame with F bit set to 1, and the data link layer entity is not in the timer-recovery condition, it shall issue an MDL-ERROR indication and process the frame as though the bit was 0.

If it is in the timer recovery state, it shall:

1) stop timer T200; start timer T203, if implemented; set V(S) to the value of the received N(R); clear any existing peer receiver busy condition and enter the multiple-frame-established state.

2) If the data link layer entity is still not in an own-receiver-busy condition:

   - if no I frame is available for transmission, the data link layer entity shall transmit an RR response with the F-bit set to 0; or

   - if an I frame is available for transmission, the data link layer entity shall transmit the I frame with the value of N(R) set to the current value of V(R) as defined in § 5.6.1 of Recommendation Q 921 [2].

3) When the data link layer entity is in an own-receiver-busy condition, it shall process the received I frame as though the P-bit is set to “0” in accordance with § 5.6.6 of Recommendation Q.921 [2]

5.6.3 *Sending and receiving acknowledgements*

The sending and receiving of acknowledgements is defined in Recommendation Q.921 [2].

5.6.4 *Receiving REJ frames*

Receiving REJ frames is defined in Recommendation Q.921 [2].

5.6.5 *Receiving RNR frames*

Receiving RNR frames is defined in Recommendation Q.921 [2].

5.6.6 *Data link layer own receiver busy condition*

Procedures for data link layer own receiver busy condition are defined in Recommendation Q.921 [2].

5.6.7 *Waiting acknowledgement*

The process of acknowledgement timing is defined in Recommendation Q.921 [2].

5.6.8 *Congestion management*

Congestion in the user plane occurs when traffic arriving at a resource exceeds the network's capacity. It can also occur for other reasons (e.g. equipment failure). Network congestion affects the throughput rate, delay and delivery of frames to the end user.

End users should reduce their offered load in the face of network congestion. Reduction of offered load by an end user will result in an increase in the effective throughput available to the end user during congestion.

If LAPF or its subset, the data link core sublayer, is used in an environment where congestion can occur, (e.g. frame relay bearer service), then some form of congestion management may be necessary:

a) In the case where LAPF is used, but the congestion control bits defined in § 3.3 are not used, then the congestion management technique described in Appendix I.1 may be used.

b) In the case where the congestion control bits of the data link layer core sublayer defined in § 3.3 are used, with or without the data link layer procedures, then the congestion management techniques described in Appendix I.1 and I.2 may be used as discussed in § A.6.

5.7 *Re-establishment of multiple frame operation*

The criteria and procedures for re-establishment of multiple frame operation are described in Recommendation Q.921 [2].

5.8 *Exception condition reporting and recovery*

Exception conditions may occur as the result of physical layer errors or data link layer procedural errors.

The error recovery procedures which are available to effect recovery following the detection of an exception condition at the data link layer are defined in this section.

The actions to be taken by the connection management entity on receipt of an MDL-ERROR indication primitive are defined in Appendix V.

### 5.8.1 *N(S) sequence error*

Processing of N(S) sequence errors is defined in Recommendation Q.921 [2].

### 5.8.2 *N(R) sequence error*

Processing of N(R) sequence errors is defined in Recommendation Q.921 [2].

### 5.8.3 *Timer recovery condition*

Definition of timer recovery conditions is in Recommendation Q.921 [2].

### 5.8.4 *Invalid frame condition*

Processing of invalid frames is defined in Recommendation Q.921 [2].

### 5.8.5 *Frame rejection condition*

A frame rejection condition results from one of the following conditions:

- the receipt of a frame with an undefined command and response field;
- the receipt of a supervisory frame or an unnumbered frame with an incorrect length;
- the receipt of an invalid N(R); or
- the receipt of a frame with an I field that exceeds the maximum established length.

Upon occurrence of a frame rejection condition while in multiple frame operation, the data layer entity shall:

- issue an MDL-ERROR indication primitive;
- optionally, transmit an FRMR response toward the peer data link layer entity; and
- initiate re-establishment (see § 5.7.2 of Recommendation Q.921 [2]).

The processing of frame reject conditions at other times and information on detecting unbounded frames are found in Recommendation Q.921 [2].

### 5.8.6 *Receipt of an FRMR response frame*

Processing of FRMR response frames received is defined in Recommendation Q.921 [2].

### 5.8.7 *Unsolicited response frames*

The action to be taken on receipt of an unsolicited response frame is defined in Table 5/Q.922.

The data link layer entity shall assume possible multiple address assignment on the receipt of an unsolicited UA response and shall inform layer management.

TABLE 5/Q.922

**Actions taken on receipt of unsolicited response frames**

| Unsolicited response frame | TEI-assigned | Awaiting establishment | Awaiting release | Multiple frame modes of operation | |
|---|---|---|---|---|---|
| | | | | Established mode | Time recovery mode |
| UA response F = 1 | MDL-ERROR indication | Solicited | Solicited | MDL-ERROR indication | MDL-ERROR indication |
| UA response F = 0 | MDL-ERROR indication | MDL-ERROR indication | MDL-ERROR indication | MDL-ERROR indication | MDL-ERROR indication |
| DM response F = 1 | Ignore | Solicited | Solicited | MDL-ERROR indication | Re-establishment MDL-ERROR indication |
| DM response F = 0 | Establish | Ignore | Ignore | Re-establishment MDL-ERROR indication | Re-establishment MDL-ERROR indication |
| Supervisory response F = 1 | Ignore | Ignore | Ignore | MDL-ERROR indication | Solicited |
| Supervisory response F = 0 | Ignore | Ignore | Ignore | Solicited | Solicited |
| I response F = 1 | Ignore | Ignore | Ignore | Treat: F = 0 MDL-ERROR indication | Solicited |

## 5.9 *List of system parameters*

The system parameters listed below are associated with each individual data link connection.

The term default implies that the value defined should be used in the absence of any assignment or negotiation of alternative values. Methods of parameter negotiation are described in § 5.4 for those parameters which are negotiable.

The system parameters which may be negotiated are:

– T200 (see § 5.9.1)

– N201 (see § 5.9.3)

– k (see § 5.9.4)

– T203 (see § 5.9.5).

#### 5.9.1 *Timer T200*

The default value for the retransmission timer (T200), at the end of which transmission of a frame may be initiated according to the procedures described in § 5.6, shall be 1.5 seconds. For the frame relay bearer service, if the cumulative transit delay (CTD) is available, then T200 may be calculated by the data link layer management as follows:

$$RTD = 2 \times CTD$$

$$T200 = \max (3 \times RTD, 1.5\ s)$$

where

CTD Cumulative transit delay.

RTD Round trip delay.

T200 Retransmission timer. The factor of 3 in calculating T200 is required to avoid out-of-range acknowledgements.

max(a,b) The larger value of a or b.

#### 5.9.2 *Maximum number of retransmissions (N200)*

The retransmission counter (N200) is a system parameter which identifies the maximum number of retransmissions of a frame and has the default value 3.

#### 5.9.3 *Maximum number of octets in an Information field (N201)*

The default for the number of octets in an information field is 260 octets. All other maximum values are negotiated between users and network and between networks (see Recommendation Q.933 [3]).

The support by networks of a negotiated maximum value of at least 1598 octets is strongly recommended for applications such as LAN (local area network) interconnection to minimize the need for segmentation and reassembly by the user equipment.

#### 5.9.4 *Maximum number of outstanding I frames (k)*

The maximum number (k) of sequentially numbered I frames that may be outstanding (that is, unacknowledged) at any given time is a system parameter which shall not exceed 127. This parameter is also called “maximum window size”

For a 16 kbits link, the default value shall be 3. For a 64 kbits link, the default value shall be 7. For a 384 kbits link, the default value shall be 32. For a 1.536 Mbits or 1.920 Mbits link, the default value shall be 40.

#### 5.9.5 *Timer T203*

The idle timer (T203) represents the maximum time allowed without frames being exchanged and has the default value 30 seconds.

### 5.10 *Data Link layer monitor function*

The operation of the data link monitor function is described in Recommendation Q.921 [2].

## ANNEX A

(to Recommendation Q.922)

**Core aspects of Q.922 for use with frame relaying bearer service**

### A.1 *General*

This annex describes the core aspects of Q.922 for use with the frame relaying bearer service by identifying the differences between the main text of this Recommendation and the structure necessary to support a frame relaying protocol.

This annex contains the frame structure, elements of procedure, format the fields and procedures for the proper operation of the frame relaying FMBS layer 2 protocol as described in Recommendation I.122 [11] and service description Recommendation I.233 [1]. The core aspects of Q.922 provide for transparent transfer of DL-CORE service user data.

*Note* – The core aspects of Q.922 as defined in this annex may be used with or without the elements of procedures of LAPF.

This protocol is a subset of LAPF. It is intended to:

– share the core functions of LAPF as defined in Recommendation I.233 [1];

– be used on any ISDN channel; and

– operate on the D-channel concurrently with the LAPD protocol as defined in Recommendation Q.921 [2].

It assumes that data link identification is determined via group signalling or by prior agreement. Group signalling is defined in Appendix II.

The core functions of LAPF used to support the frame relaying bearer service are considered to be:

– frame delimiting, alignment and transparency,

– frame multiplexing/demultiplexing using the address field;

– inspection of the frame to ensure that it consists of an integral number of octets prior to zero bit insertion of following zero bit extraction;

– inspection of the frame to ensure that it is neither too long nor too short;

– detection of (but not recovery from) transmission errors; and

– congestion control functions.

### A.2 *Frame structure for peer-to-peer communication*

#### A.2.1 *General*

All data link layer peer-to-peer exchanges are in frames conforming to the format shown in Figure A-l/Q.922.

#### A.2.2 *Flag sequence*

See § 2.2.

#### A.2.3 *Address field*

The address field shall consist of at least two octets, as illustrated in Figure A-l/Q.922 but may optionally be extended up to 4 octets. The format of the address field is defined in § A.3.2.

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
|---|---|---|---|---|---|---|---|---|
| Flag | | | | | | | | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | O( |
| High order octet of address field | | | | | | (Note) | | 2 |
| Low order octet of address field | | | | | | | | 3 |
| | | | | | | | | 4 |
| Frame relay information field | | | | | | | | |
| | | | | | | | | N- |
| Frame check sequence (FCS) 1st octet | | | | | | | | N- |
| Frame check sequence (FCS) 2nd octet | | | | | | | | N- |
| Flag | | | | | | | | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | N |

*Note* – The default address field length is 2 octets. It may be extended to either 3 or 4 octets bilateral agreement.

FIGURE A-1/Q922

**Frame relay frame format with two octet address**

A.2.4 *Control field*

A control field, as seen by the DL-CORE Sublayer, does not exist in a frame relay frame structure.

A.2.5 *Frame relaying information field*

The frame relaying information field of a frame, when present, follows the address field (see § A.3.2) and precedes the frame check sequence field (see § A.2.7). The contents of the frame relaying information field shall consist of an integral number of octets.

The maximum number of octets in the frame relaying information field is defined in § A.5.1.

A.2.6 *Transparency*

A transmitting data link layer entity shall examine the frame content between the opening and closing flag sequences, (address, information and FCS fields) and shall insert a "0" bit after all sequences of five contiguous "1" bits (including the last five bits of the FCS) to ensure that a flag or an abort sequence is not simulated within the frame. A receiving data link layer entity shall examine the frame contents between the opening and closing flag sequences and shall discard any "0" bit which directly follows five contiguous "1" bits.

A.2.7 *Frame checking sequence (FCS) field*

The definition and use of the FCS is as described in § 2.7.

### A.2.8 *Format convention*

The definitions of formats and numbering conventions are as describe in § 2.8.

### A.2.9 *Invalid frames*

The definition of invalid frames is as described in § 2.9.

If a frame which is too long is received by the network, the network may:

– discard the frame (see Note);

– send part of the frame toward the destination user, then abort the frame; or

– send the complete frame toward the destination user with a valid FCS.

*Note* – This approach implies that the implementation of the Q.922 protocol can not exploit the capabilities to discriminate among corrupted or too long frames.

Selection of one or more of these behaviors is an option for designers of frame relay network equipment and is not subject to further standardization. Users shall not make any assumption as to which of these actions the network will take. In addition, the network may optionally clear the frame relay call if the number or frequency of too-long frames exceeds a network specified threshold.

### A.2.10 *Frame abort*

The definition of and reaction to a frame abort is discussed in § 2.10.

## A.3 *Elements of procedures and formats of fields for the DL-CORE service sublayer*

### A.3.1 *General*

The elements of procedures contained in this annex are used by the DL-CORE service sublayer to implement optional procedures for congestion management which are found in § A.6.

### A.3.2 *Address field format*

The format of the address field is shown in Figure A-2/Q.922. This field includes the address field extension bits, a bit reserved for use by end user equipment intended to support a command/response indication, forward and backward congestion notification bits, discard eligibility indication, an indicator for DLCI or DL-CORE control interpretation of a 3 or 4 octet “address field" and a data link identification (DLCI) field. The minimum and default length of the address field is 2 octets and it may be extended to 3 or 4 octets to support a larger DLCI address range or to support the optional DL-CORE control functions. The 3-octet or 4-octet address field formats may be supported at the user-network interface or the network-network interface based on bilateral agreement.

### A.3.3 *Address field variables*

#### A.3.3.1 *Address field extension bit (EA)*

The definition and use of the EA bit is discussed in § 3.3.1.

#### A.3.3.2 *Command/response bit C/R*

The C/R bit is not used by the DL-CORE protocol. The coding is application specific. The C/R bit is conveyed transparently by the DL-CORE protocol between DL-CORE services users.

#### A.3.3.3 *Forward explicit congestion notification (FECN)*

This bit may be set by a congested network to notify the user that congestion avoidance procedures should be initiated where applicable for traffic in the direction of the frame carrying the FECN indication. This bit is set to 1 to indicate to the receiving end-system that the frames it receives have encountered congested resources. This bit may be used by destination controlled transmitter rate adjustment.

Default address field format (2 Bytes)

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td colspan="6">Upper DLCI</td><td>*</td><td>EA<br>0</td></tr>
<tr><td colspan="4">Lower DLCI</td><td>FECN</td><td>BECN</td><td>DE</td><td>EA<br>1</td></tr>
</table>

or

3 octet address field format

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td colspan="6">Upper DLCI</td><td>*</td><td>EA<br>0</td></tr>
<tr><td colspan="4">DLCI</td><td>FECN</td><td>BECN</td><td>DE</td><td>EA<br>0</td></tr>
<tr><td colspan="6">Lower DLCI or<br>DL-CORE control</td><td>D/C</td><td>EA<br>1</td></tr>
</table>

or

4 octet address field format

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td colspan="6">Upper DLCI</td><td>*</td><td>EA<br>0</td></tr>
<tr><td colspan="4">DLCI</td><td>FECN</td><td>BECN</td><td>DE</td><td>EA<br>0</td></tr>
<tr><td colspan="7">DLCI</td><td>EA<br>0</td></tr>
<tr><td colspan="6">Lower DLCI or<br>DL-CORE control</td><td>D/C</td><td>EA<br>1</td></tr>
</table>

D/C DLCI or DL-CORE control indicator (see § A.3.3.7)

DE Discard eligibility indicator (see § A.3.3.5)

EA Address field extension bit (see § A.3.3.1)

* Bit intended to support a command/response indication. The coding is application specific (see § A.3.3.2)

FECN Forward explicit congestion notification (see § A.3.3.3)

BECN Backward explicit congestion notification (see § A.3.3.4)

DLCI Data link connection identifier (see § A.3.3.6)

FIGURE A-2/Q.922

**Address field formats**

While setting this bit by the network or user is optional, no network shall ever clear (set to 0) this bit. Networks that do not provide FECN shall pass this bit unchanged. An example of the use of this bit is contained in Appendix I.

A.3.3.4 *Backward explicit congestion notification (BECN)*

This bit may be set by a congested network to notify the user that congestion avoidance procedures should be initiated, where applicable for traffic in the opposite direction of the frame carrying the BECN indicator. This bit is set to 1 to indicate to the receiving end-system that the frames it transmits may encounter congested resources. This bit may be used by source controlled transmitter rate adjustment.

While setting this bit by the network or user is optional, no network shall ever clear (set to 0) this bit. Networks that do not provide BECN shall pass this bit unchanged. An example of the use of this bit is contained in Appendix I.

A.3.3.5 *Discard eligibility indicator (DE)*

This bit, if used, is set to 1 to indicate a request that a frame should be discarded in preference to other frames in a congestion situation. Setting of this bit by the network or user is optional. No network shall ever clear (set to 0) this bit. Networks that do not provide DE shall pass this bit unchanged. Networks are not constrained to discard only frames with DE = 1 in the presence of congestion.

A.3.3.6 *Data link connection identifier (DLCI)*

The DLCI has a default length of 10 bits. The extension bit may be used to optionally increase the length to 16, 17 or 23 bits, as shown in Figure A-2/Q.922. The ranges for the DLCI values are shown in Table 1/Q.922. As discussed in § 3.3.7, the D/C indication may affect the length of the DLCI.

A.3.3.7 *DLCI/DL-CORE control indicator (D/C)*

The definition and use of D/C are discussed in § 3.3.7.

A.4 *Placement of the DL-CORE protocol in the ISDN protocol architecture*

This section describes the placement of the DL-CORE protocol in the context of a layered architecture. The concepts of the OSI reference model (see Recommendation X.200 [12]), the OSI service conventions (see Recommendation X.210 [13]), and the ISDN protocol reference model (see Recommendation I.320 [14]) are used. The definition of layer to layer communication and a general introduction to the functional model is given in § 4. For this annex, a representative model is presented also for the sublayer communication with the DL-CORE Sublayer.

The Figures A-3/Q.922 and A-4/Q.922 depict the model which represents primitive interactions with messages for the support of the core service according to Recommandation I.233 [1].

The U-plane layer 2 is subdivided into:

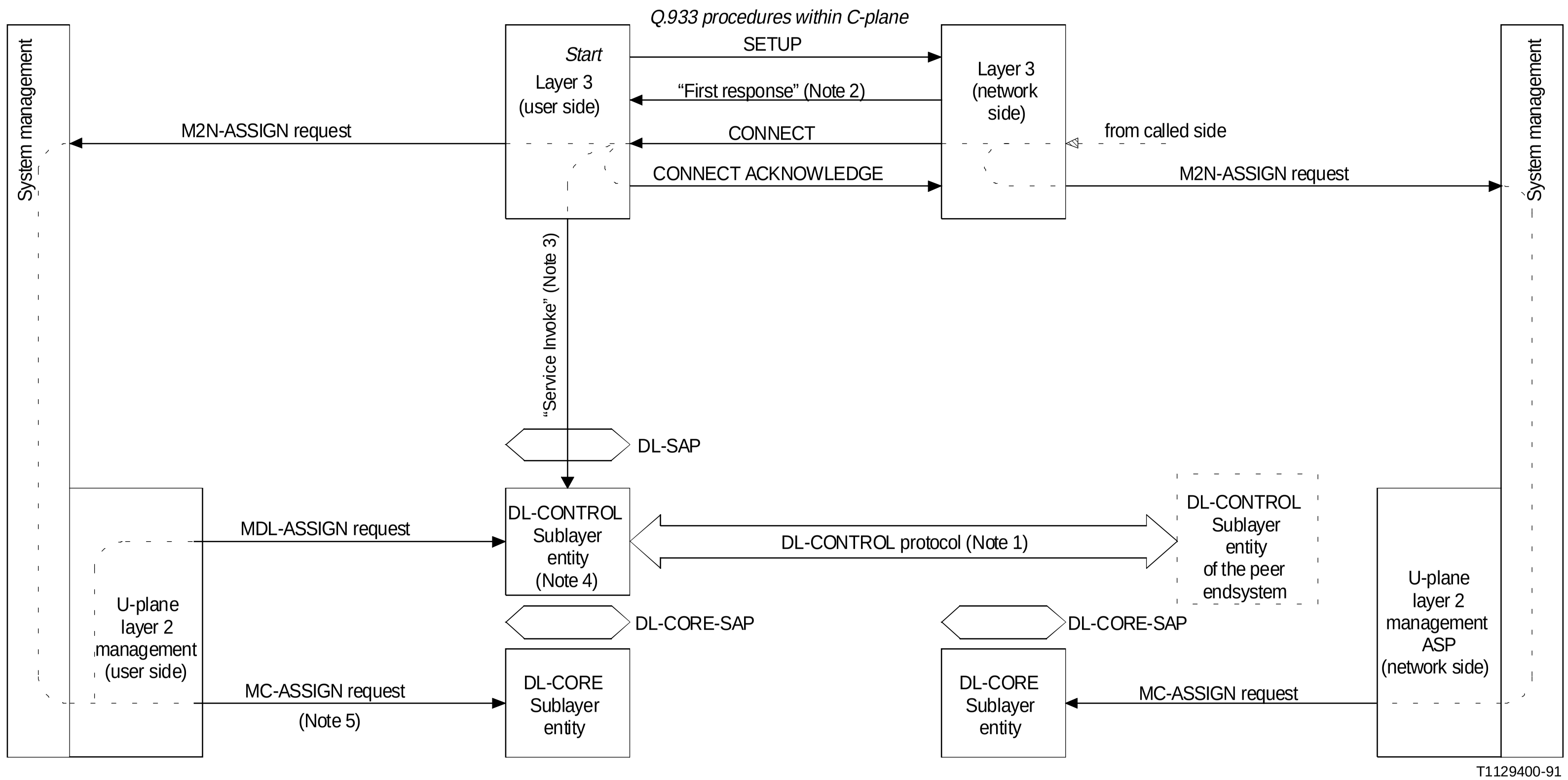
a) a DL-CONTROL Sublayer; and

b) a DL-CORE Sublayer.

The DL-CORE Sublayer provides core services to the user, a DL-CONTROL Sublayer, at the DL-CORE-SAP.

The model shown in the figures covers both frame relaying and frame switching. In the case of frame relaying, the DL-CONTROL Sublayer entities at the network side are not present.

The signal flows are based upon those shown in Figures 3/Q.922 through 6/Q.922. Figure A-3/Q.922 depicts the signal flows at the calling access and called access interfaces. Figure A-4/Q.922 depicts the signal flows at the releasing access and released access interfaces.




*Note 1* – The DL-CONTROL protocol may be a Q.922 protocol procedure, another CCITT specified protocol, or any protocol between endsystems which, as a DL-CORE service user, is compatible with the DL-CORE sublayer services.

*Note 2* – The reserved DLCI is indicated in the first response to the SETUP message, e.g., CALL PROCEEDING.

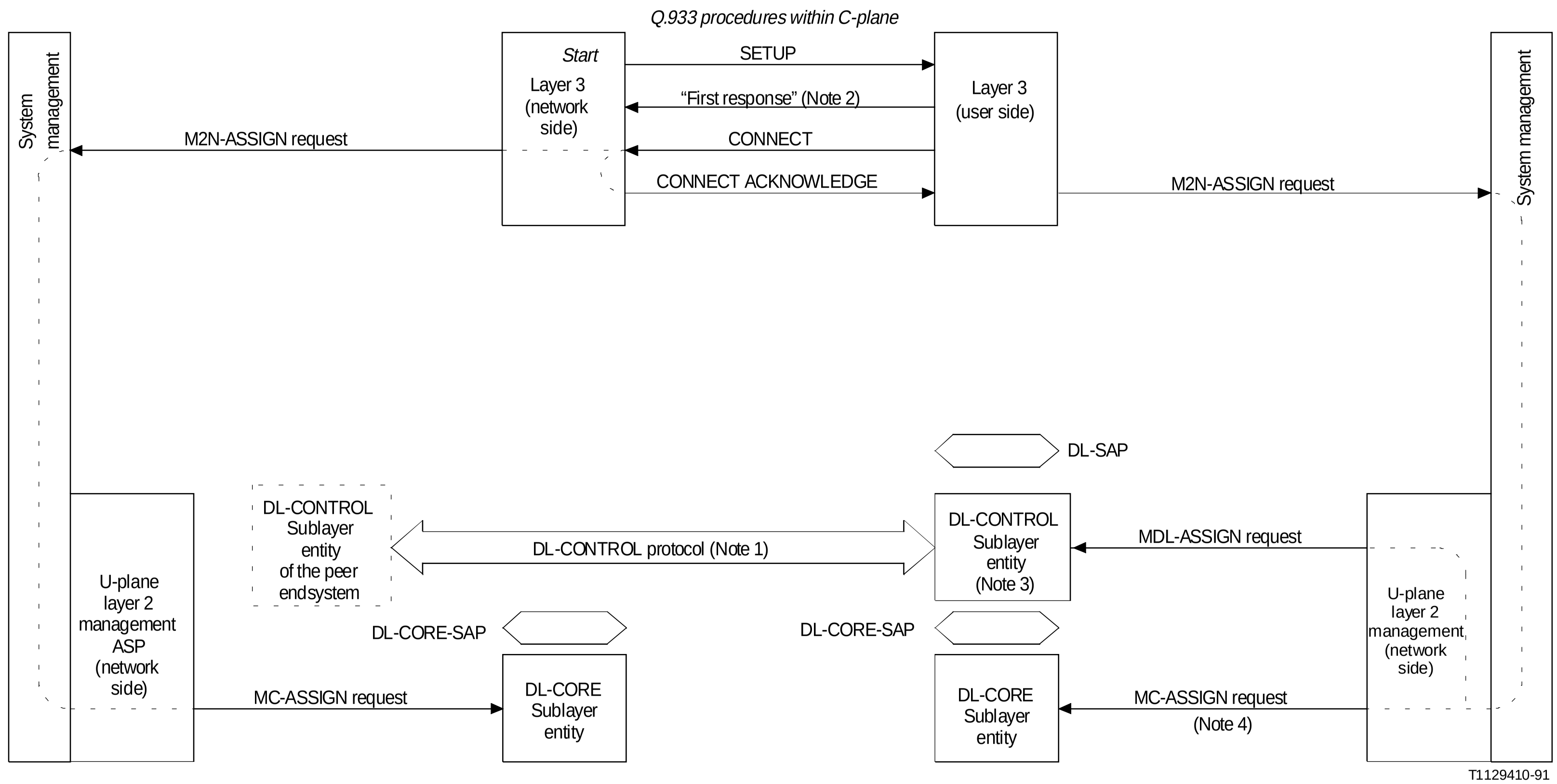
*Note 3* – The "service invoke" is not further defined in this Recommendation since it depends on the service provided by the DL-CONTROL Sublayer.

*Note 4* – For frame relaying, this DL-CONTROL Sublayer entity established the U-plane Layer 2 connection between the two endsystems. Since there is no DL-CONTROL Sublayer entity present at the network side (calling side), no collision is enforced between the U-plane Layer 2 PDUs, if any, establishing the U-plane link.

*Note 5* – This reflects the case when the MC-ASSIGN request is received prior to the DL-CORE DATA request; otherwise, an MC-ASSIGN indication would be issued to acquire a DLCI.

FIGURE A-3/Q.922 (sheet 1 of 2)

**Relationship of primitives with messages for core services connection establishment**




*Note 1* – The DL-CONTROL protocol may be a Q.922 protocol procedure, another CCITT specified protocol, or any protocol between endsystems which, as a DL-CORE service user, is compatible with the DL-CORE sublayer services.

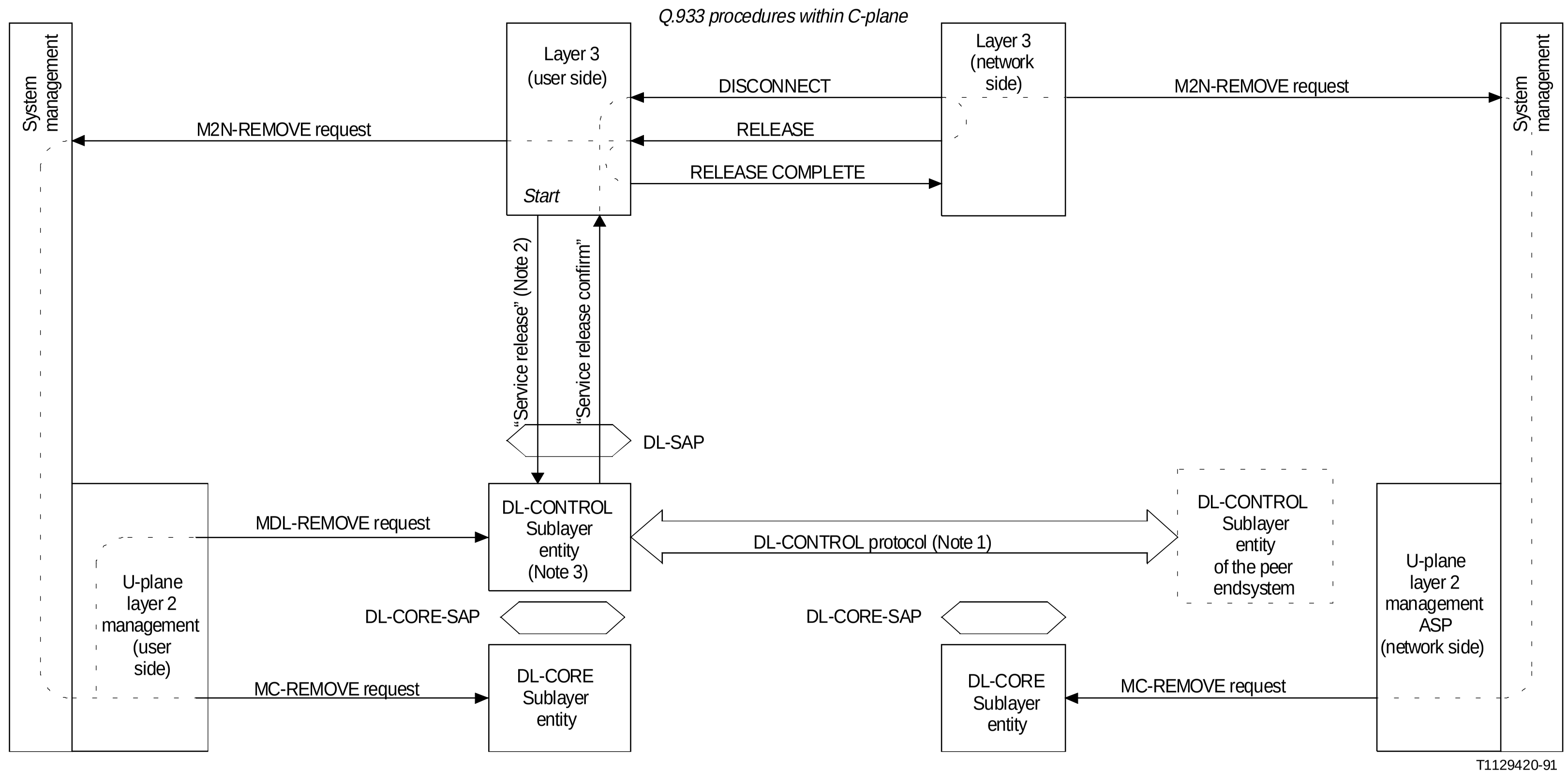
*Note 2* – The reserved DLCI is indicated in the first response to the SETUP message, e.g., CALL PROCEEDING.

*Note 3* – For frame relaying, this DL-CONTROL Sublayer entity established the U-plane Layer 2 connection between the two endsystems. Since there is no DL-CONTROL Sublayer present at the network side (calling side), no collision is enforced between the U-plane Layer 2 PDUs, if any, establishing the U-plane link.

*Note 4* – This reflects the case when the MC-ASSIGN request is received prior to the DL-CORE DATA request; otherwise, an MC-ASSIGN indication would be issued to acquire a DLCI.

FIGURE A-3/Q.922 (sheet 2 of 2)

**Relationship of primitives with messages for core services connection establishment**



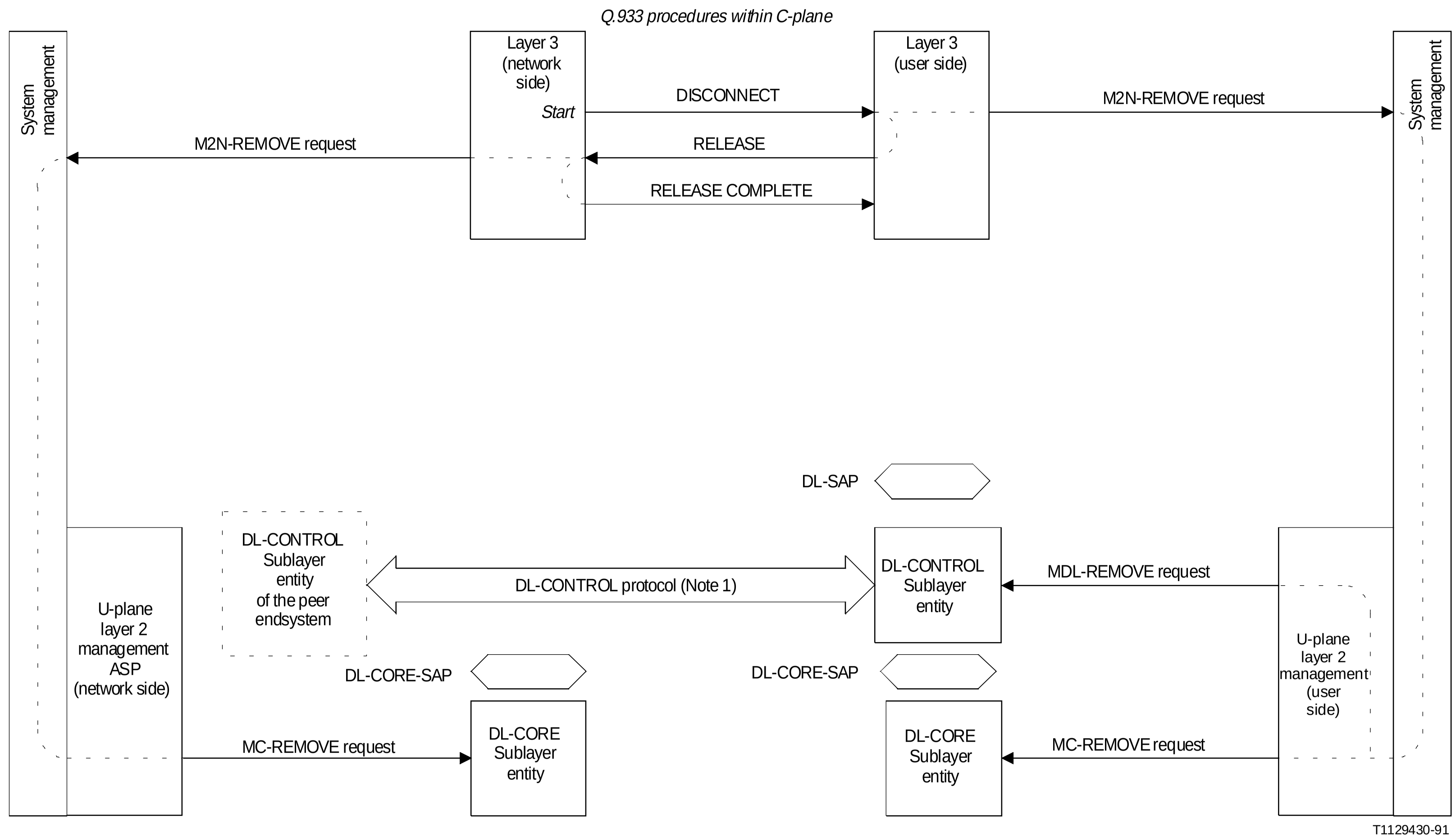

*Note 1* – The DL-CONTROL protocol may be a Q.922 protocol procedure, another CCITT specified protocol, or any protocol between endsystems which, as a DL-CORE service user, is compatible with the DL-CORE sublayer services.

*Note 2* – The "service release" is not further defined in this Recommendation since it depends upon the service provided by the DL-CONTROL Sublayer. The "service release confirm" is required to avoid premature release of the connection within the C-plane.

*Note 3* – For frame relaying, this DL-CONTROL Sublayer entity releases the U-plane Layer 2 connection between the two endsystems. Since there is no DL-CONTROL Sublayer entity present at the network side (released side), no collision is enforced between the U-plane Layer 2 PDUs, if any, releasing the U-plane link.

FIGURE A-4/Q.922 (sheet 1 of 2)

**Relationship of primitives with messages for core services connection establishment**




*Note 1* – The DL-CONTROL protocol may be a Q.922 protocol procedure, another CCITT specified protocol, or any protocol between endsystems which, as a DL-CORE service user, is compatible with the DL-CORE sublayer services.

FIGURE A-4/Q.922 (sheet 2 of 2)

**Relationship of primitives with messages for core services connection establishment**

Table A-l/Q.922 illustrates the primitives defined for the core aspects of LAPF.

TABLE A-1/Q.922

**Primitive types**

| Generic name | Type | | | | Parameter | | Message unit contents |
|---|---|---|---|---|---|---|---|
| | Re-quest | Indi-cation | Response | Confirmation | Priority indicator | Message unit | |
| Layer 3 — Layer 2 management | | | | | | | |
| M2N-ASSIGN | X | — | — | — | — | X | DL-CEI, DLCI (Note 1) |
| M2N-REMOVE | X | — | — | — | — | X | DLCI |
| DL-Core user — DL-Core | | | | | | | |
| DL-CORE-DATA | X | X | — | — | — | X | See § A.4.2.2 |
| DL-CONTROL — Layer 2 management | | | | | | | |
| MDL-ASSIGN | X | — | — | — | — | X | DL-CORE CEI, DL-CEI |
| MDL-REMOVE | X | — | — | — | — | X | DL-CORE CEI |
| DL-Core — Layer 2 management | | | | | | | |
| MC-ASSIGN | X | X | — | — | — | X | DLCI, DL-CORE CEI |
| MC-REMOVE | X | — | — | — | — | X | DLCI |
| Layer 2 — Layer 1 | | | | | | | |
| PH-DATA | X | X | — | — | X (Note 2) | X | Data link layer peer-to-peer message |

*Note 1* — Optional parameters; if missing, default values art used or procedures of Appendix III are used.

*Note 2* — A priority indicator for layer 1 is not present in Recommendation X.211 [9] and is used only for the basic rate interface D-channel. Recommendation X.211 [9] does not consider priority as a layer 1 quality of service parameter.

A.4.1 *Support by the underlying physical layer service*

The physical layer service is defined in the OSI physical layer service definition (see Recommendation X.211 [9]). Only duplex (two-way simultaneous), point-to-point synchronous transmission is used. The optional PH-Connection activation and deactivation services of the physical layer are not presently used to support the DL-CORE protocol.

A.4.2 *DL-CORE service*

Recommendation I.233 [1] provides a layer service description for the DL-CORE Sublayer. The DL-CORE protocol is used to provide and support this layer service.

A.4.2.1 *Primitives*

The DL-CORE DATA primitives are described in Annex B of Recommendation I.233 [1].

A.4.2.2 *Parameters*

The parameters associated with the DL-CORE DATA primitives are defined in Annex C of Recommendation I.233 [1]. The mapping of these core services parameters to DL-CORE-PDU fields is as follows:

| Core service parameter (defined in Recommendation I.233 [1]) | DL-CORE DATA primitive | | DL-CORE-PDU field |
|---|---|---|---|
| | Request | Indication | |
| DL-CORE user data | X | X | Information field |
| Discard eligibility | X | | Discard eligibility |
| Congestion encountered backward | | X | BECN |
| Congestion encountered forward | | X | FECN |
| DL-CORE service user protocol control information | X | X | C/R bit |

A.4.2.3 *Procedures*

A.4.2.3.1 *Primitives/Frame relay frame mappings*

When a DL-CORE entity receives a DL-CORE DATA request from the DL-CORE service user, it sends a frame relay frame to its peer.

When a DL-CORE entity receives a valid frame relay frame, it signals a DL-CORE DATA indication to the DL-CORE service user.

A.4.2.3.2 *Parameters/fields mappings*

The parameters to the DL-CORE DATA request and DL-CORE DATA indication primitives are directly mapped to the fields of the frame relay frame as shown in § A.4.2.2.

A.4.3 *Layer management*

Table A-1/Q.922 shows the primitives exchanged between the DL-CORE Sublayer management entity and the DL-CORE Sublayer entity.

A.4.3.1 *Primitives*

A.4.3.1.1 *MC-ASSIGN request*

The MC-ASSIGN request primitive is used by the layer management entity to:

– signal to the DL-CORE Sublayer entity that a DL-CORE Connection has been established,

– convey the DLCI agreed to be used between DL-CORE entities in support of that Core-connection,

– convey the associated DL-CORE Connection Endpoint Identifier to be used uniquely identify the DL-CORE Connection and

– convey the Connection Endpoint Identifier used to support the DL-CORE Connection.

A.4.3.1.2 *MC-REMOVE request*

The MC-REMOVE request primitive is used by the layer management entity to signal to the DL-CORE Sublayer entity that a DLCI has been released.

A.4.3.1.3 *M2N-ASSIGN*

The M2N-ASSIGN primitives are defined in § 4.1.1.10.

A.4.3.1.4 *M2N-REMOVE*

The M2N-REMOVE primitives are defined in § 4.1.1.11.

A.4.3.1.5 *MDL-ASSIGN request*

The MDL-ASSIGN request establishes a mapping in the DL-CONTROL Sublayer entity between the DL-CORE CEI and the DL-CEI.

A.4.3.1.6 *MDL-REMOVE request*

The MDL-REMOVE request primitive is used by the layer 2 management entity to remove a mapping between a DL-CEI and a DL-CORE CEI.

A.4.3.2 *Parameters*

A.4.3.2.1 *DLCI value*

The DLCI value parameter conveys the DLCI agreed to be used between DL-CORE Entities in support of a DL-CORE Connection. Its syntax and usage by the protocol are defined in § 3.6.

A.4.3.2.2 *DL-CORE Connection Endpoint Identifier*

The DL-CORE CEI uniquely identifies a DL-CORE Connection. It is defined in Recommendation I.233 [1].

A.4.3.2.3 *DL-Connection Endpoint Identifier*

The DL-CEI uniquely identifies a DL-Connection.

A.4.3.2.4 *Physical Connection Endpoint Identifier*

The physical Connection Endpoint Identifier uniquely identifies a physical Connection to be used in support of a DL-CORE Connection.

A.4.3.3 *Procedures*

For permanent frame relay bearer connections, information related to the operation of the DL-CORE protocol in support of DL-CORE Connections is maintained by DL-CORE Sublayer management. For demand frame relay bearer connections, the layer 3 establishes and releases DL-CORE Connections on behalf of the DL-CORE Sublayer. Therefore, information related to the operation of the DL-CORE protocol is maintained by coordination of layer 3 management and DL-CORE Sublayer management through the operation of the local systems environment.

A.4.3.3.1 *DL-CORE connection establishment*

When it is necessary to notify the DL-CORE Sublayer entity (either because of establishment of a demand frame relay call, because of notification of re-establishment of a permanent frame relay bearer connection or because of system initialization) that a DL-CORE Connection is to be established, the DL-CORE Layer management entity signals an MC-ASSIGN request primitive to the DL-CORE Sublayer entity. In addition, the Layer 2 management entity initiates an MDL-ASSIGN request to the DL-CONTROL Sublayer entity.

The DL-CORE Sublayer entity establishes the necessary mappings between the supporting physical Connection, the DL-CORE CEI and the DLCI. In addition, if it has not already done so, it begins to transmit flags on the physical Connection.

The DL-CONTROL Sublayer entity establishes the necessary mappings between the DL-CORE CEI and the DL-CEI.

A.4.3.3.2 *DL-CORE connection release*

When it is necessary to notify the DL-CORE Sublayer entity (either because of release of a demand frame relay call or because of notification of failure of a permanent frame relay bearer connection) that a DL-CORE Connection is to be released the DL-CORE Layer management entity signals an MC-REMOVE request primitive to the DL-CORE Sublayer entity, and an MDL-REMOVE request to the DL-CONTROL Sublayer entity.

The DL-CORE Sublayer entity removes any mappings between the supporting physical Connection, the DL-CORE CEI and the DLCI.

The DL-CONTROL Sublayer entity removes any mapping between the DL-CORE CEI and the DL-CEI.

## A.5 *List of system parameters*

The system parameters listed below are associated with each individual frame relaying connection.

### A.5.1 *Maximum number of octets in a frame relaying information field (N203)*

The default for the maximum number of octets in a frame relaying information field is 262 octets (i.e. N201 + 2). The minimum frame relaying information field size is one octet. The default maximum size was chosen for compatible operation with LAPD on the D-channel, which has a 2 octet control field and a 260 octet maximum information field. All other maximum values are negotiated (e.g. using Q.933 procedures) between users and networks and between networks. The support by networks of a negotiated maximum value of at least 1600 octets is strongly recommended for applications such as LAN interconnection to minimize the need for segmentation and reassembly by the user equipment.

## A.6 *Congestion control procedures*

Congestion in the user plane occurs when traffic arriving at a resource exceeds the network’s capacity. It can also occur for other reasons (e.g. equipment failure). Network congestion affects the throughput rate, delay and frame loss experienced by the end user.

End users should reduce, their offered load in the face of network congestion. Reduction of offered load by an end user may well result in an increase in the effective throughput available to the end user during congestion.

Congestion control may be achieved by:

i) congestion avoidance mechanisms, and/or

ii) congestion recovery mechanisms.

Congestion avoidance (see Note) mechanisms, as discussed in §§ A.6.2 and A.7, are used at the onset of congestion to minimize its negative effect on the network and the user.

*Note* – Congestion avoidance, as defined in Recommendtion I.370 [10], is intended to minimize degradation in the quality of service. The specification of the degree of degradation is beyond the scope of this Recommendation.

Congestion recovery mechanisms, as defined in § A.6.1, are used to prevent network collapse in the face of severe congestion.

Congestion avoidance and congestion recovery are effective and complementary forms of congestion control in frame relaying networks.

### A.6.1 *Implicit congestion detection*

For implicit congestion detection schemes, the frame relaying network does not send an indication to the user. Implicit congestion schemes involve certain events available in the layer 2 elements of procedures to detect the frame loss (e.g. receipt of a REJECT frame, timer recovery, etc.).

The intent of this scheme is to reduce the offered load to the network by the end user. Use of such reduction by users is optional. An example of one approach is discussed in § I.1.

### A.6.2 *Explicit notification*

Explicit notification is a procedure used for congestion avoidance. Explicit notification is a part of the data transfer phase protocol. Users should react to explicit congestion notification (i.e. the reaction is a highly desirable option). Users that are not able to act on explicit congestion notification shall have the capability to receive and ignore explicit notification generated by the network.

Reaction by the end user to the receipt of explicit congestion notification is rate based.

#### A.6.2.1 *Explicit congestion signals*

Explicit congestion signals are sent in both forward (towards frame destination) and backward (towards frame source) directions. Forward explicit congestion notification is provided by using the FECN bit in the address field. Backward explicit congestion notification is provided by one of two methods. When timely reverse traffic is available, the BECN bit in an appropriate address field may be used. Otherwise, a single consolidated link layer management message may be generated by the network (see § A.7). The Consolidated link layer management (CLLM) message travels on the U-plane physical path. The generation and transport of CLLM by the network is optional.

All networks must transport the FECN and BECN bits without resetting.

#### A.6.2.2 *Rate reduction strategy*

The specific rate reduction strategy to be used by end users is not identified. An example is discussed in § I.2.

## A.7 *Consolidated link layer management (CLLM) message*

The consolidated link layer management message is based on ISO 8885 [15] definition of the use of XID frames for the transport of functional information. The generation and transport of the CLLM are optional. Figures A-5/Q.922 and A-6/Q.922 illustrate the format of this frame. Each parameter is described using the sequence type – length – value. The following subsections describe the functional fields for the consolidated link layer management message. All fields are binary encoded unless otherwise specified.

| Octet | Bits<br>8 7 6 5 4 3 2 1 | Field name |
|---|---|---|
| 1 | 1 1 1 1 1 0 R 0 | Address octet 1 (R indicates “response”) |
| 2 | 1 1 1 1 0 0 0 1 | Address octet 2 |
| 3 | 1 0 1 0 1 1 1 1 | XID control field |
| 4 | 1 0 0 0 0 0 1 0 | Format identifier (130) |
| 5 | 0 0 0 0 1 1 1 1 | Group identifier = 15 (Private parameters negotiation) |
| 6 | | Group length octet 1 |
| 7 | | Group length octet 2 |
| 8 | 0 0 0 0 0 0 0 0 | Parameter identifier = 0 (Parameter set identification) |
| 9 | 0 0 0 0 0 1 0 0 | Parameter length (4) |
| 10 | 0 1 1 0 1 0 0 1 | Parameter value = 105 (IA5 coded I) |
| 11 | 0 0 1 1 0 0 0 1 | Parameter value = 49 (IA5 coded 1) |
| 12 | 0 0 1 1 0 0 1 0 | Parameter value = 50 (IA5 coded 2) |
| 13 | 0 0 1 1 0 0 1 0 | Parameter value = 50 (IA5 coded 2) |
| 14 | 0 0 0 0 0 0 1 0 | Parameter identifier = 2 (cause id) |
| 15 | 0 0 0 0 0 0 0 1 | Parameter length = 1 |
| 16 | | Cause value |
| 17 | 0 0 0 0 0 0 1 1 | Parameter value = 3 (DLCI identifier) |
| 18 | | Parameter length |
| 19 | | DLCI value octet 1 |
| 20 | | DLCI value octet 2 |
| // | | // |
| 2n + 17 | | DLCI value octet (n-th DLCI) |
| 2n + 18 | | DLCI value octet (n-th DLCI) |
| 2n + 19 | | FCS octet 1 |
| 2n + 20 | | FCS octet 2 |

FIGURE A-5/Q.922

**Consolidated link layer management message (B- or H-channel) using 2 octet address field**

| Octet | Bits | Field name |
|---|---|---|
| | 8 7 6 5 4 3 2 1 | |
| 1 | 1 1 1 1 1 0 R 0 | Address octet 1 (SAPI = 62) (R indicates “response”) |
| 2 | 1 1 1 1 1 1 1 1 | Address octet 2 (TEI = 127) |
| 3 | 1 0 1 0 1 1 1 1 | XID control field |
| 4 | 1 0 0 0 0 0 1 0 | Format identifier (130) |
| 5 | 0 0 0 0 1 1 1 1 | Group ident. = 15 (Private parameters negotiation) |
| | | Octet 6 to 2n + 18 as for B- or H-channels in Figure A-5/Q.922 |
| | // | // |
| 2n + 19 | | FCS octet 1 |
| 2n + 20 | | FCS octet 2 |

FIGURE A-6/Q.922

**Consolidated link layer management message (D-channel) using 2 octet address field**

A.7.1 *Address octets*

The default address size of two octets is used in the following specification.

*Note* – The use of CLLM for 3 or 4 octet address fields is for further study.

Octets 1 and 2 represent the address field for a default two octet address. The first octet includes the 6 bit upper DLCI subfield. The second octet includes the 4 bit lower DLCI subfield.

The CLLM message is sent in an XID-response frame. Except when delivered on a D-channel, it is sent in the management DLCI as shown in Figure A-5/Q.922. The congestion indication bits and the discard eligibility indicator are not used in this case and should be set to “0”. When delivered on the D-channel, it is sent using a two octet address field with bits 8 to 4 of the first address field octet and bits 8 to 2 of the second address field octet set to “1” and bit 3 of the first octet set to “0” as shown in Figure A-6/Q.922. The congestion indication bits and the discard eligibility indicator do not exist in this case.

*Note* – The use of the CLLM for semi-permanent frame relay connections using D-channel access requires further study.

Octets 1 and 2 of the XID frame represent the address field and bit 2 of octet 2 is the command/response bit (C/R). In a congestion control application, the receipt of a congestion message should not result in transmission of a subsequent frame, which would add to the traffic congestion. Therefore, the CLLM shall be sent in an XID response frame, i.e. the C/R bit shall be set to “1”.

A.7.2 *Control field*

Octet 3 contains the control field code point for this type of message. This represents the control field for XID.

A.7.3 *XID information field*

A.7.3.1 *Format identifier field*

Octet 4 contains the format identifier field. ISO defines the format identifier field to have a length of one octet. ISO 8885 [15] assigns the value of 130 decimal as a general purpose format identifier, and it is used by layer management for parameter negotiation as discussed in Appendix III.

A.7.3.2 *Group field*

A.7.3.2.1 *Group identifier field*

Octet 5 contains the group identifier field. The group identifier field is "15" decimal, which is assigned by ISO 8885 [15] to indicate private parameters.

*Note* – In the context of ISO 8885 [15]-Addendum 3, "private" is taken to mean a parameter beyond the scope of the HDLC specific parameters defined in ISO 8885 [15].

A.7.3.2.2 *Group length field*

Octets 6 and 7 contain the group length field. This 16-bit field describes the "length" of the octets in the remainder of the group field. The maximum value of the group length field is 256 for compatibility with the D-channel applications where the information field is a maximum of 260 octets.

A.7.3.2.3 *Group value field*

The group value field consists of two or more parameter fields. The parameter Set identification, parameter 0, identifies the set if private parameters within the group value field per ISO 8885 [15]/DAD 3. The other parameters shall appear in the following order: cause identifier and then DLCI identifier.

A.7.3.3 *Parameter for parameter Set identification*

The parameter Set identification parameter shall always be present; otherwise, the frame shall be rejected.

A.7.3.3.1 *Parameter Set identification field*

Octet 8 contains the parameter identifier field for the first parameter and is set to "0" per ISO 8885 [15]/DAD 3. Parameter 0 identifies the set of private parameters within this group.

A.7.3.3.2 *Parameter Set identification length field*

Octet 9 contains the length of parameter 0 and is set to binary "4".

A.7.3.3.3 *Parameter value field*

Octets 10 to 13 identify that this usage of the XID frame private parameter group is for I.122 [11] private parameters. Octet 10 contains the IA5 value of "I" (binary 105). Octet 11 contains the IA5 value of "1" (binary 49). Octets 12 and 13 each contain the IA5 value of "2" (binary 50).

A.7.3.4 *Parameter field for cause identifier*

The cause identifier shall always be present; otherwise, the frame shall be ignored.

A.7.3.4.1 *Parameter identifier field*

Octet 14 contains the cause identifier field. When the parameter identifier field is set to "2", then the following octets of this parameter contain a length parameter set to "1" and a cause value.

A.7.3.4.2 *Parameter length field*

Octet 15 contains the length of the cause identifier. This shall be set to binary "1".

A.7.3.4.3 *Cause value*

Octet 16 contains the cause value. This octet identifies the cause of this message as determined by the congested network node whose layer management module originated the message.

| Bits<br>8 7 6 5 4 3 2 1 | Cause |
|---|---|
| 0 0 0 0 0 0 1 0 | Network congestion due to excessive traffic — short term |
| 0 0 0 0 0 0 1 1 | Network congestion due to excessive traffic — long term |
| 0 0 0 0 0 1 1 0 | Facility or equipment failure — short term |
| 0 0 0 0 0 1 1 1 | Facility or equipment failure — long term |
| 0 0 0 0 1 0 1 0 | Maintenance action — short term |
| 0 0 0 0 1 0 1 1 | Maintenance action — long term |
| 0 0 0 1 0 0 0 0 | Unknown — short term |
| 0 0 0 1 0 0 0 1 | Unknown — long term |
| All other values are reserved | |

The CLLM message shall not be ignored solely because of an unknown cause value.

*Note* – Cause values shall be coded as "short term" if the CLLM is sent due to a transient condition (e.g. one anticipated to have a duration on the order of seconds or minutes); otherwise, they shall be coded as "long term". Usage shall be network specific.

A.7.3.5 *Parameter field for DLCI identifier*

If the DLCI identifier is missing, then the frame shall be ignored.

A.7.3.5.1 *Parameter identifier field*

When the parameter identifier field is set to "3", then the following octets of this parameter contain the DLCI(s) of the frame relay bearer connection(s) that are congested.

A.7.3.5.2 *Parameter length field*

Octet 18 contains the length of the DLCI(s) being reported, in octets. For example, if (n) DLCIs are being reported and they are of length two octets each, this will be 2 times (n) in octet size.

A.7.3.5.3 *Parameter value field*

Octets 19 through to the FCS octets contain the DLCI value(s) which identify logical link(s) that have encountered a congested state. The DLCI field is 10 bits long and contained in bits 8 to 3 of the first octet pair and bits 8 to 5 of the next octet of the pair. The bit 8 of the first octet is the most significant bit and bit 5 of the second octet is the least significant. The bits 2 to 1 in the first octet and bits 4 to 1 in the second octet are reserved.

A.7.4 *FCS field*

The last two octets of the frame contain the frame check sequence field.

A.7.5 *Action of the congested node*

When a node becomes congested, it may send notification of the congested state by setting forward and backward congestion bits to “1” in the address field and/or using a consolidated link layer management message on the management data link. The purposes of the explicit congestion notification are:

1) to inform the edge node at the network ingress of the congestion so that the edge node can take appropriate action to reduce network congestion; and/or

2) to notify the source that negotiated throughput has been exceeded.

The consolidated link layer management message contains a list of DLCIs that correspond to the congested frame relay bearer connections. These DLCIs will correspond both to sources that are currently active and those that are not. The purpose of the latter action is to prevent those sources from becoming active and hence increasing congestion. It may be necessary to send more than one consolidated link layer management message, if all DLCIs cannot fit within a single frame.

# ANNEX B

(to Recommendation Q.922)

**SDL for point-to-point procedures**

B.1 *General*

The purpose of this annex is to provide one example of an SDL representation of the point-to-point procedures of the data link layer, to assist in the understanding of this Recommendation. This representation does not describe all of the possible actions of the data link layer entity, as a non-partitioned representation was selected in order to minimize its complexity. The SDL representation, therefore, does not constrain implementations from exploiting the full scope of the procedures as presented within the text of this Recommendation. The text description of the procedures is definitive.

The representation is a peer-to-peer model of the point-to-point procedures of the data link layer and is applicable to the data link layer entities at both the user and network sides for all ranges of DLCIs. The model is the same as that used for Recommendation Q.921 [2] and Figure B-1/Q.922 demonstrates a graphical representation of the model.

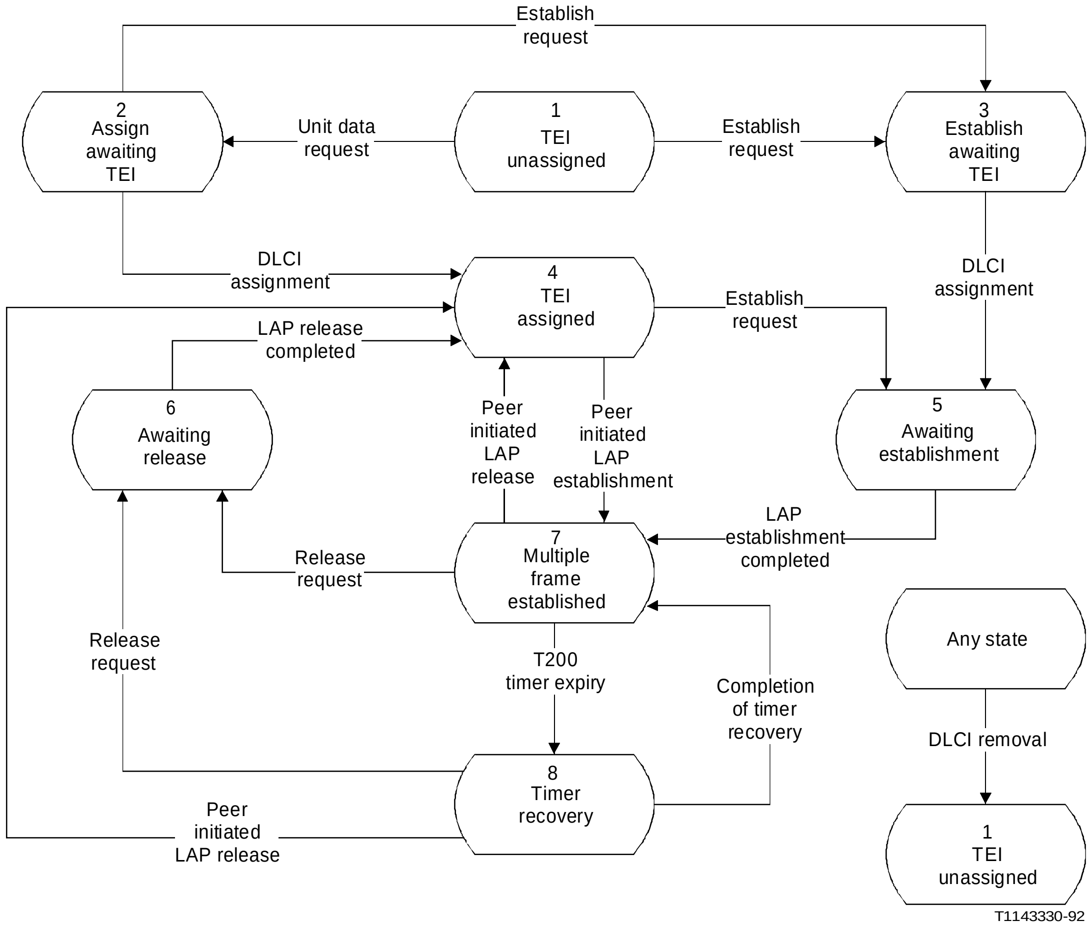



FIGURE B-1/Q.922

**An overview of the states of the point-to-point procedures**

B.2 *An overview of the states of the point-to-point data link layer entity*

The SDL representation of the point-to-point procedures is based upon an expansion of the three basic states identified in § 3.4.2 of Recommendation Q.920 [7] to the following 8 states:

State 1 *TEI unassigned*

State 2 *Assign awaiting TEI*

State 3 *Establishing awaiting TEI*

State 4 *TEI assigned*

State 5 *Awaiting establishment*

State 6 *Awaiting release*

State 7 *Multiple frame established*

State 8 *Timer recovery*

An overview of the inter-relationship of these states is provided in Figure B-1/Q.922. This overview is incomplete, and serves only as an introduction to the SDL representation. All data link layer entities are conceptually initiated in the *TEI unassigned* state (state 1), and will interact with the layer management to request a DLCI value. DLCI assignment initiated by a unit data request will cause the data link layer entity to move to the *TEI assigned* state (state 4) via the *assigned awaiting TEI* state (state 2). Initiation by an establishment request will cause a transition to the *awaiting establishment* state (state 5) via the *establish awaiting TEI* state (state 3). In states 4 to 8, unit data requests can be directly serviced by the data link layer entity. The receipt of an establish request in the *TEI assigned* state (state 4) will cause the initiation of the establishment procedures and the transition to the *awaiting establishment* state (state 5). Completion of the LAP establishment procedures takes the data link layer entity into the *multiple frame established* state (state 7). In the *multiple frame established* state (state 7), acknowledged data transfer requests can be serviced directly subject to the restrictions of the procedures. Expiry of timer T200, which is used in both the flow control and data transfer aspects of the data link layer entity's procedure initiates the transition to the *timer recovery* state (state 8). Completion of the timer recovery procedures will return the data link layer entity to the *multiple frame established* state (state 7). In states 7 and 8 of the SDL representation the following conditions which are identified within the Recommendation are observed:

a) peer receiver busy,

b) reject exception,

c) own receiver busy.

In addition, other conditions are used to avoid indentification of additional states.

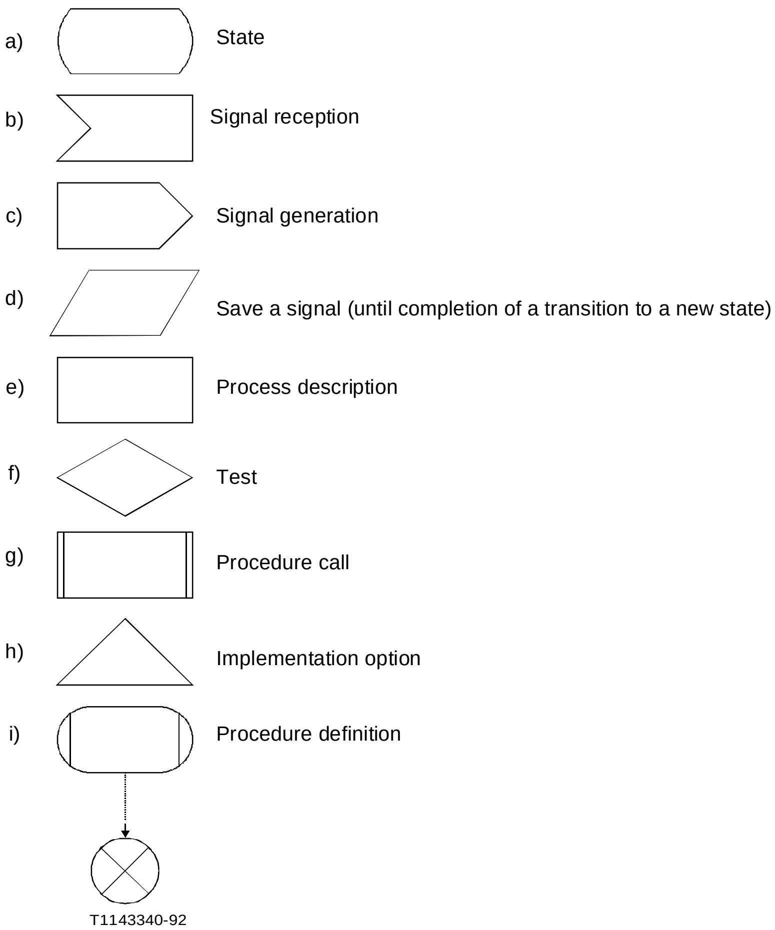
A peer initiated LAP release will take the data link layer entity directly into the *TEI assigned* state (state 4), while a release request will be via the *awaiting release* state (state 6). DLCI removal will cause a transition to the *TEI unassigned* state (state 1).

## B.3 *Catalogue of symbols used*

The following symbols and abbreviations are used within this description. A full description of the symbols and their meaning and application can be found in the Series-Z Recommendations (Fascicles X.1 to X.5).

## B.4 *The use of queues*

To enable a satisfactory representation of the data link layer entity, conceptual queues for the UI frame and I frame transmission have been explicitly brought out. These conceptual queues are finite but unbounded and should in no way restrict the implementation of the point-to-point procedures. Two additional signals have been provided in order to cause the servicing of these queues to be initiated – UI frame queued up and I frame queued up.




j) *** To mark an event or signal required as a result of the representation approach adopted, which is local to the data link layer entity.

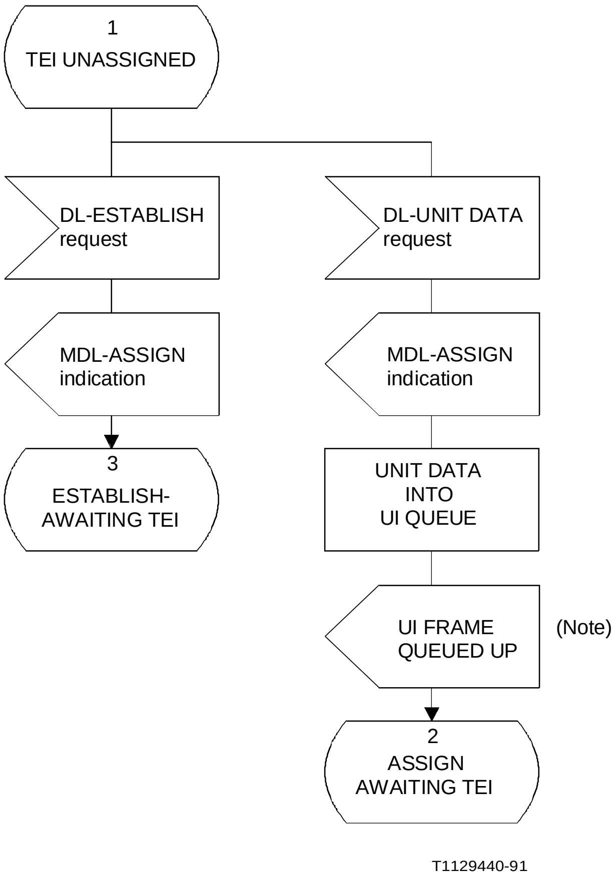
k) RC Retransmission counter

l) (A-O) The codes used in the MDL-ERROR indication signals are defined in Table V-1/Q.922. When multiple codes are shown, only one applies.

FIGURE B-2/Q.922

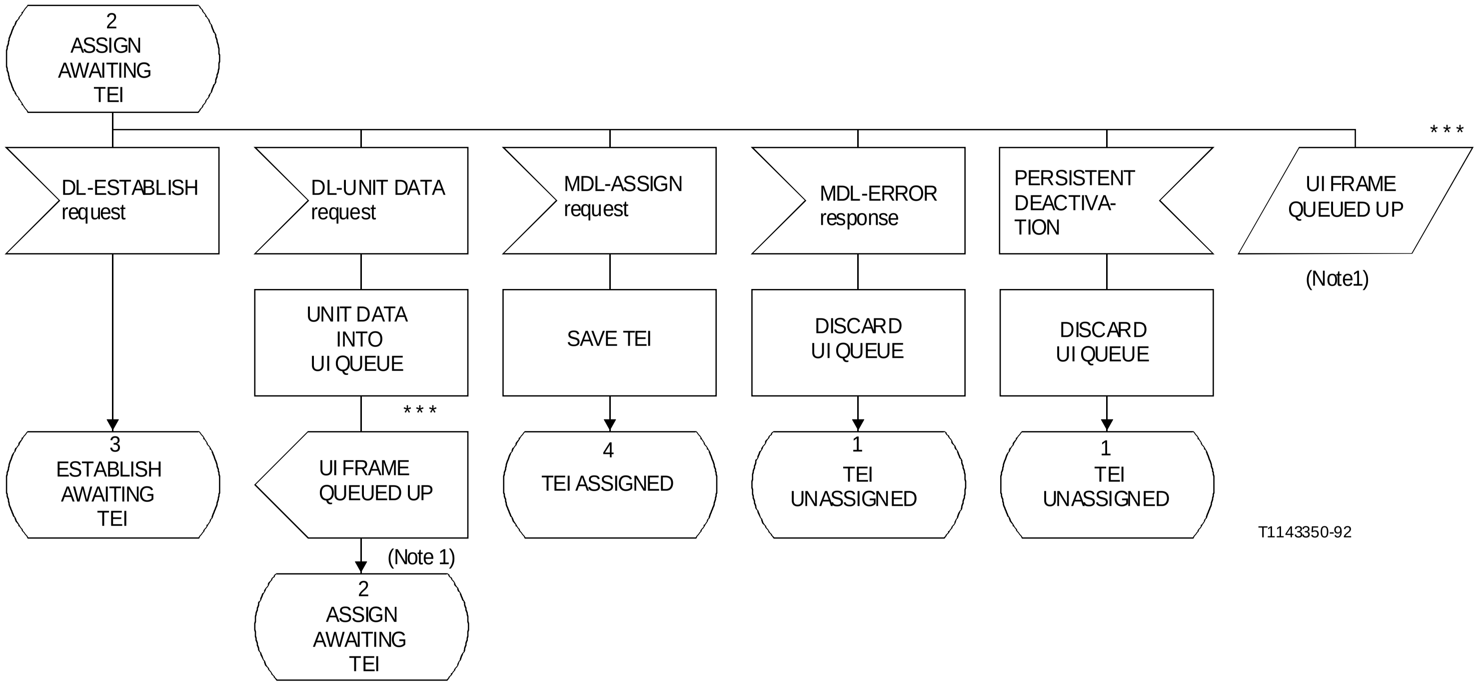
**Notation used in SDL figures**

## B.5 *SDL representation*




*Note* – Processing of UI frame queued up is described in Figure B-9/Q.922.

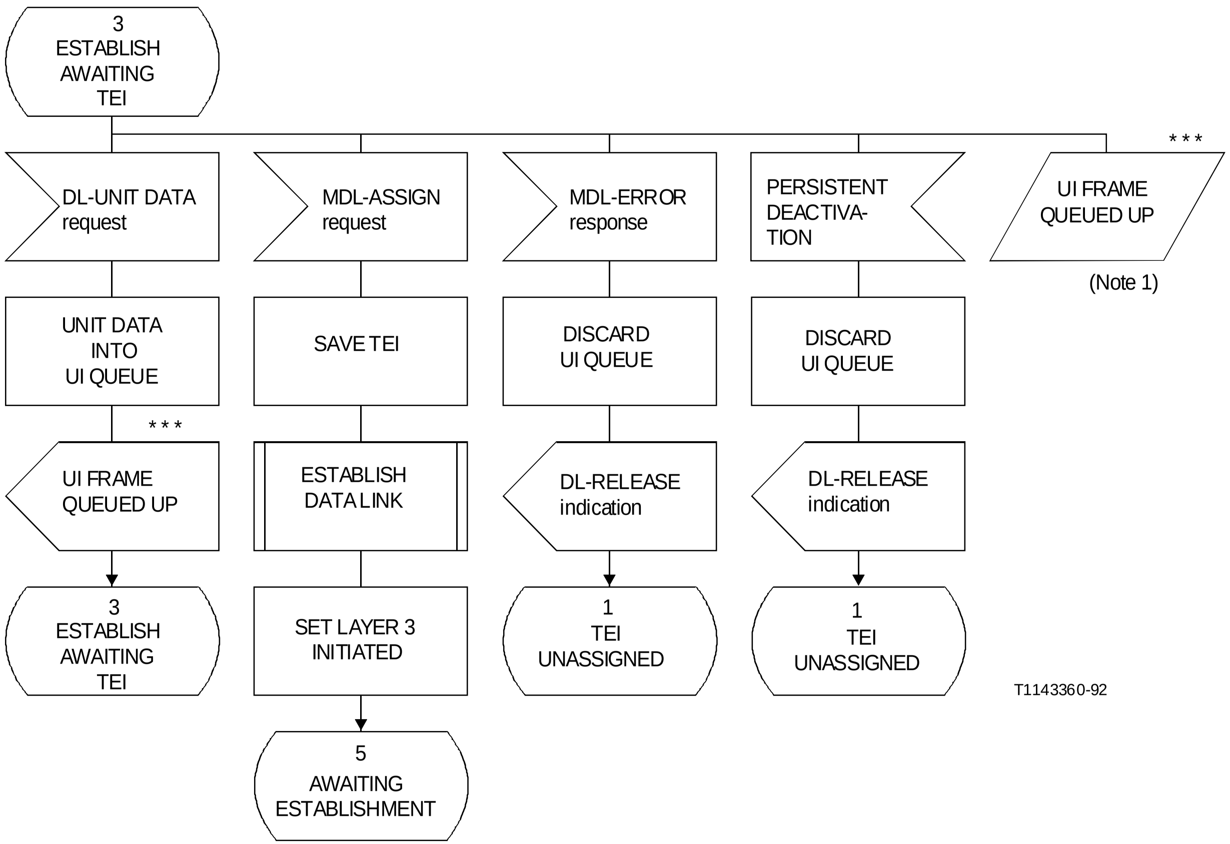
FIGURE B-3/Q.922 (sheet 1 of 3)




*Note 1* – Processing of UI frame queued up is described in Figure B-9/Q.922.

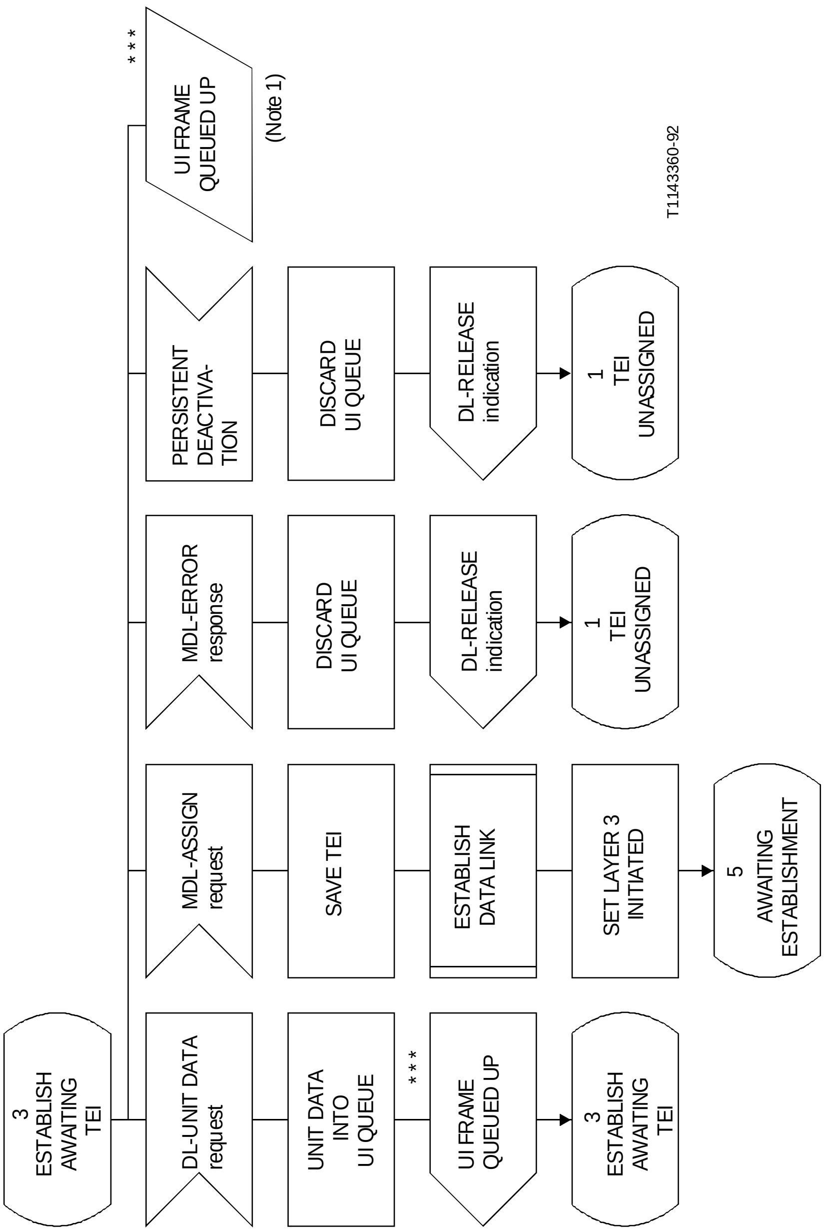
*Note 2* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-3/Q.922 (sheet 2 of 3)



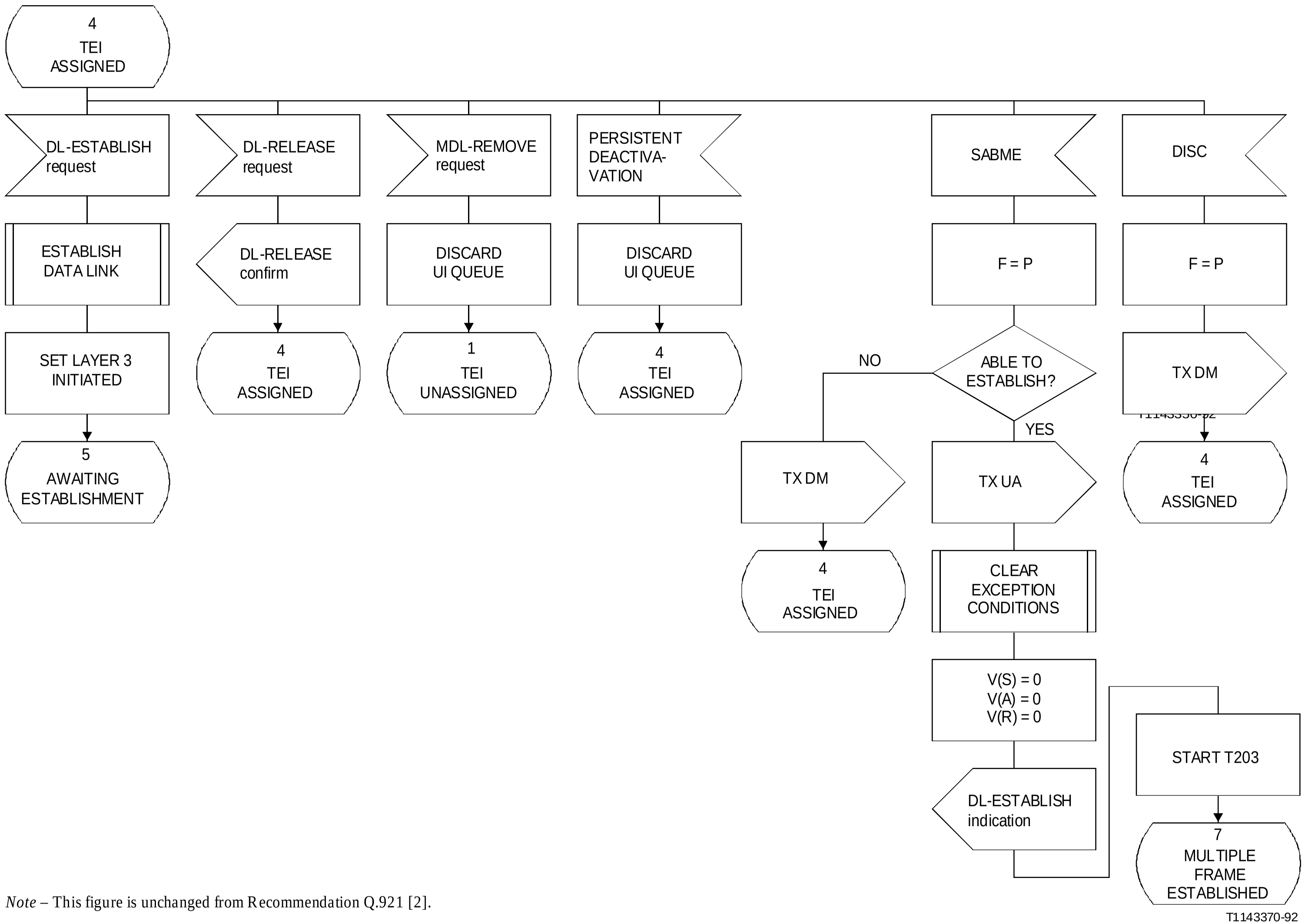

*Note 1* – Processing of UI frame queued up is described in Figure B-9/Q.922.
*Note 2* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-3/Q.922 (sheet 3 of 3)



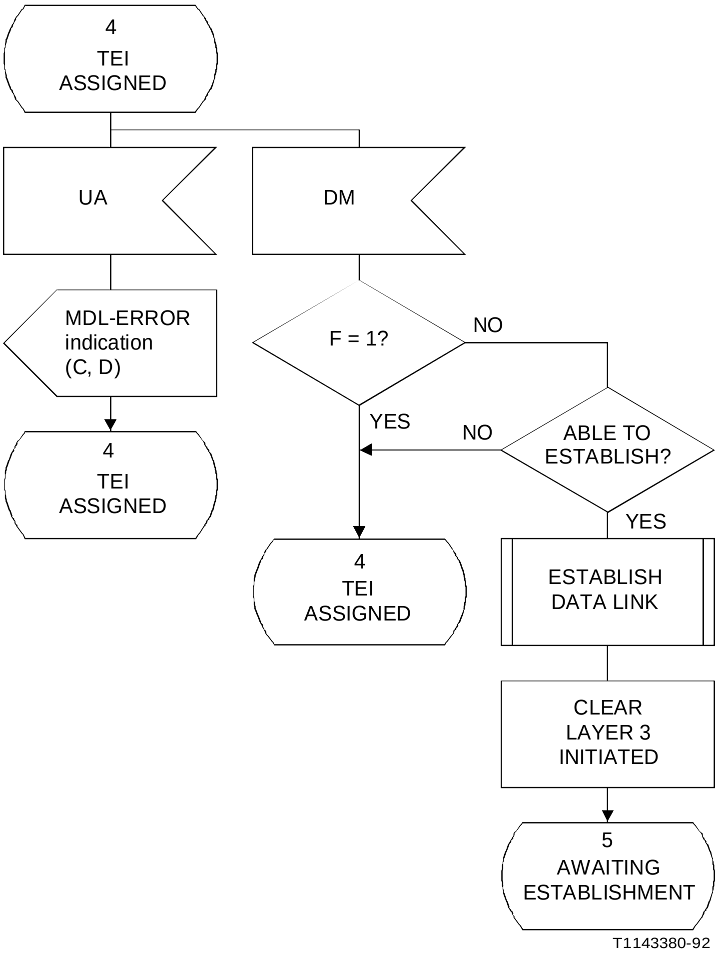

*Note 1* – Processing of UI frame queued up is described in Figure B-9/Q.922.
*Note 2* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-3/Q.922 (sheet 3 of 3)



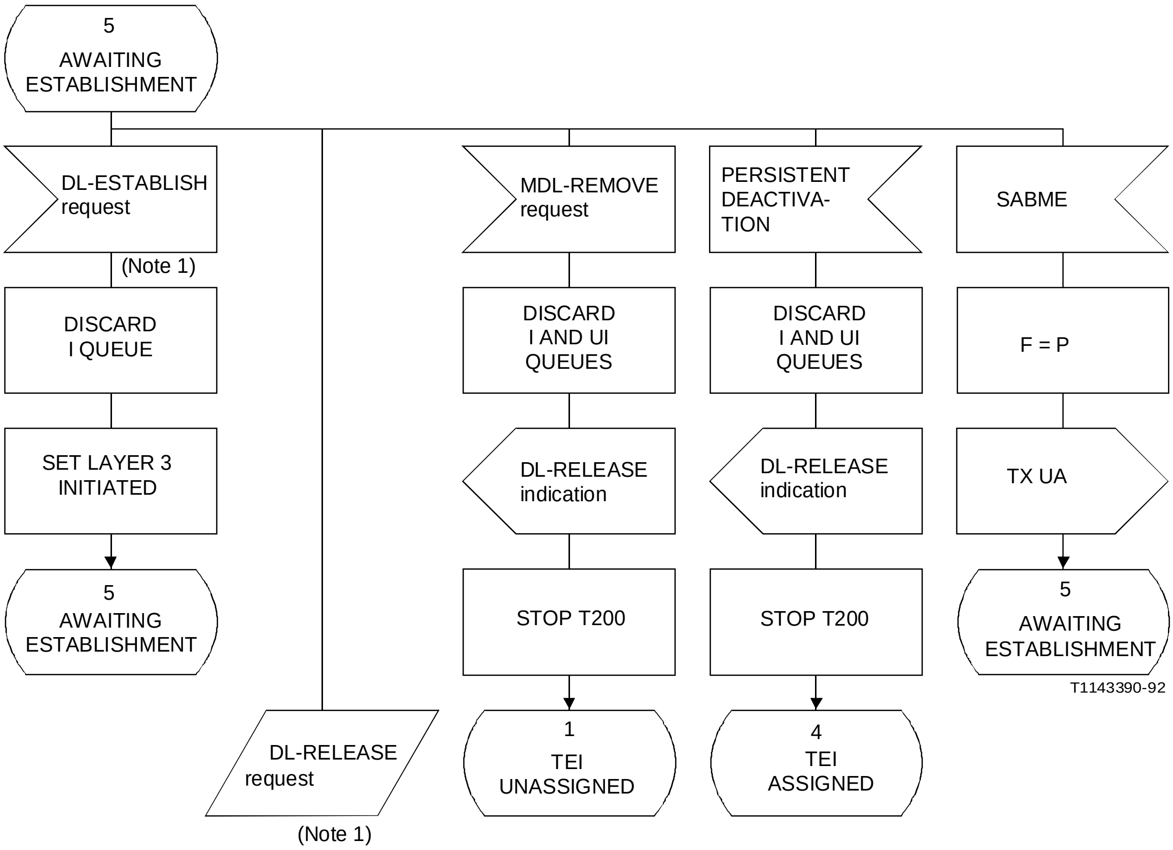

*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-4/Q.922 (sheet 1 of 2)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

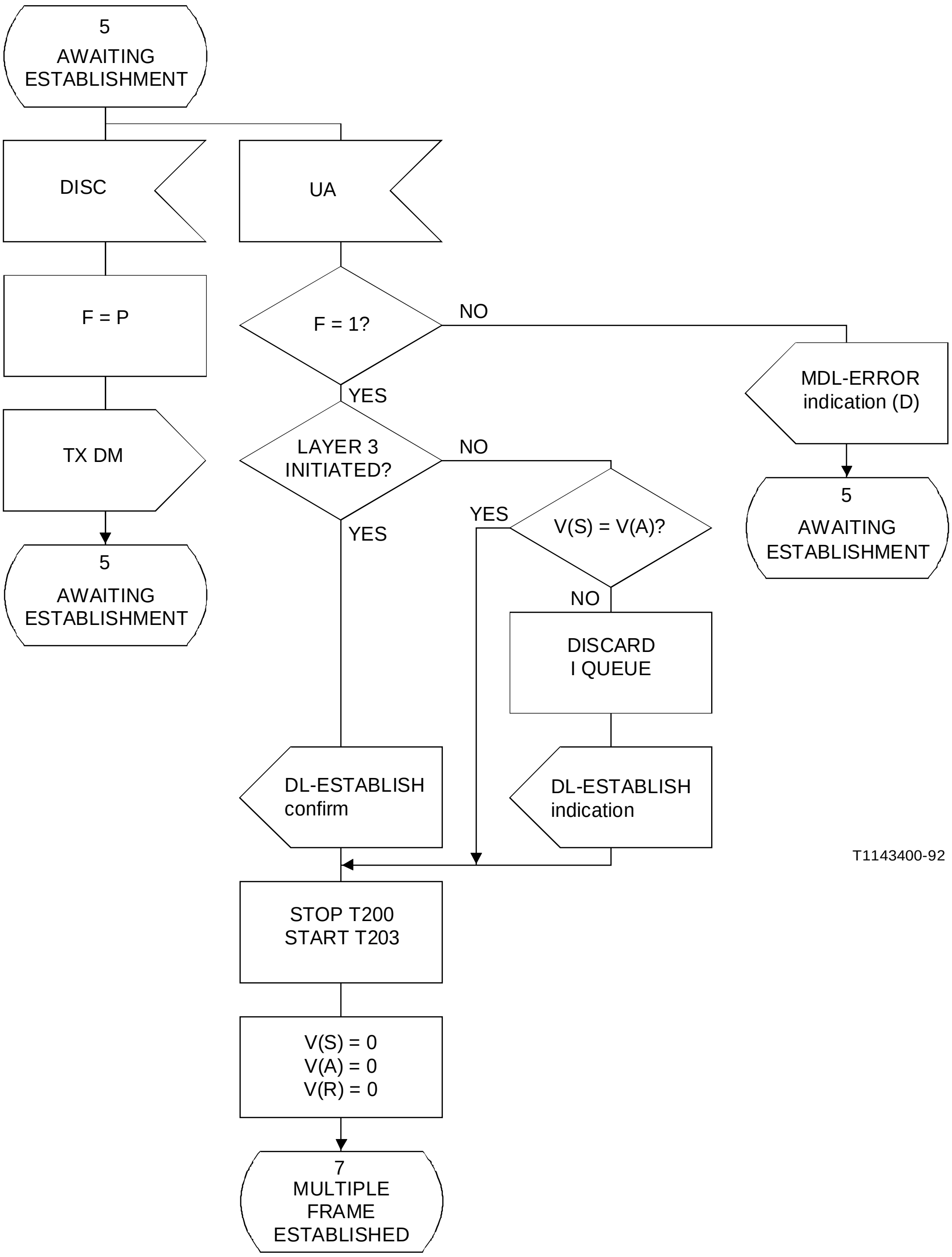
FIGURE B-4/Q.922 (sheet 2 of 2)




*Note 1* – Only possible in cases of layer 2 initiated re-establishment.

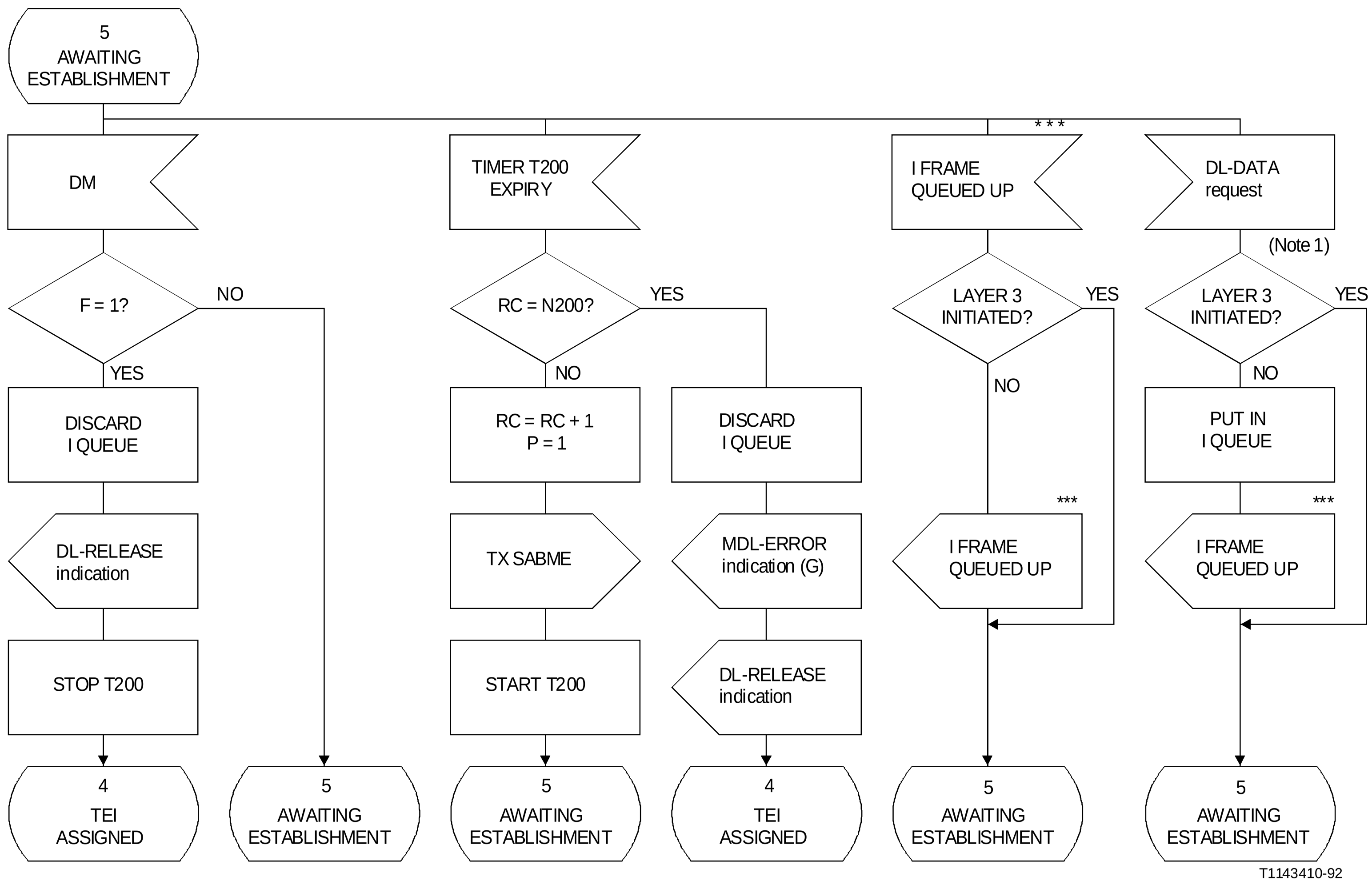
*Note 2* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-5/Q.922 (sheet 1 of 3)

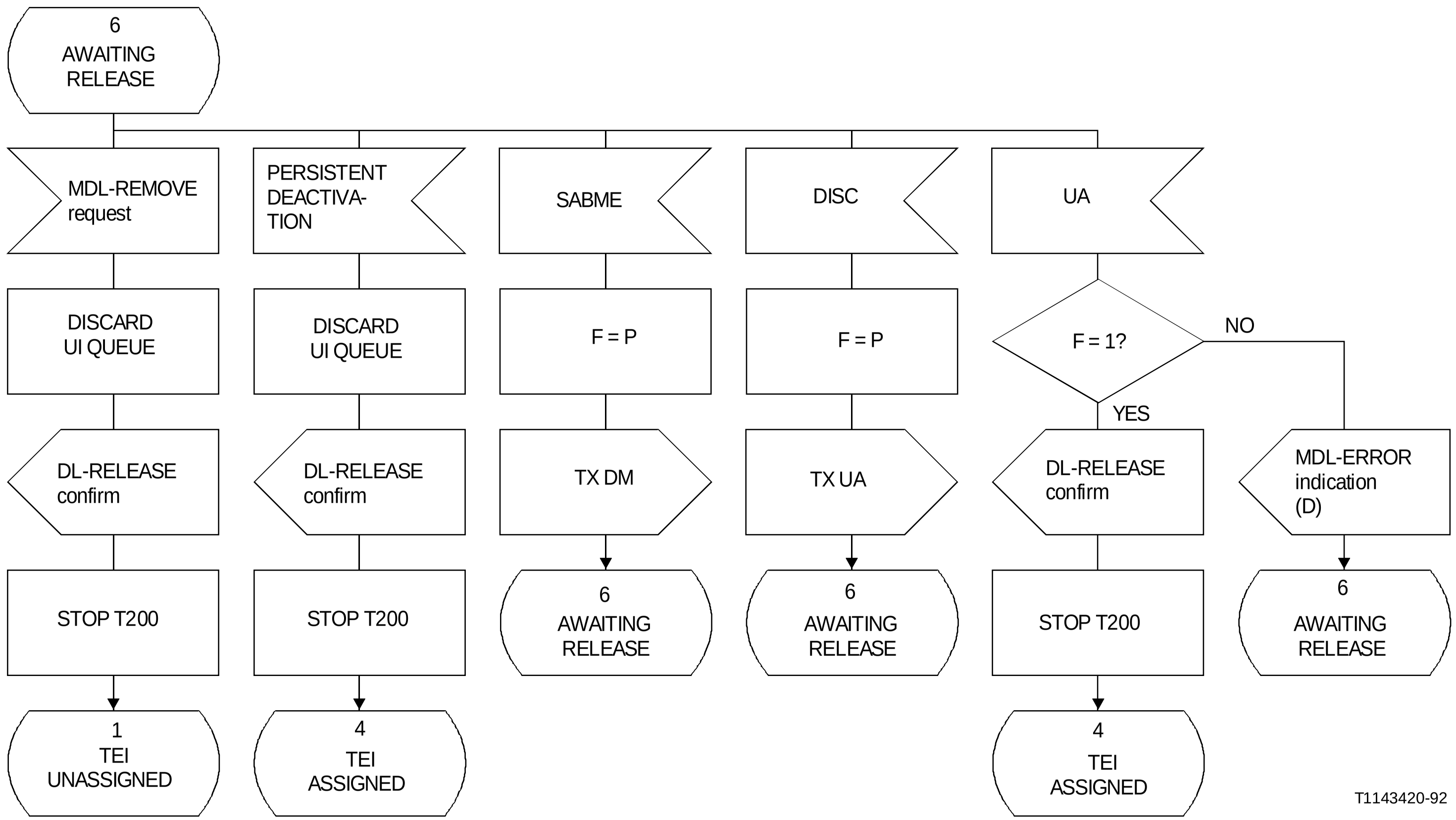



*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-5/Q.922 (sheet 2 of 3)

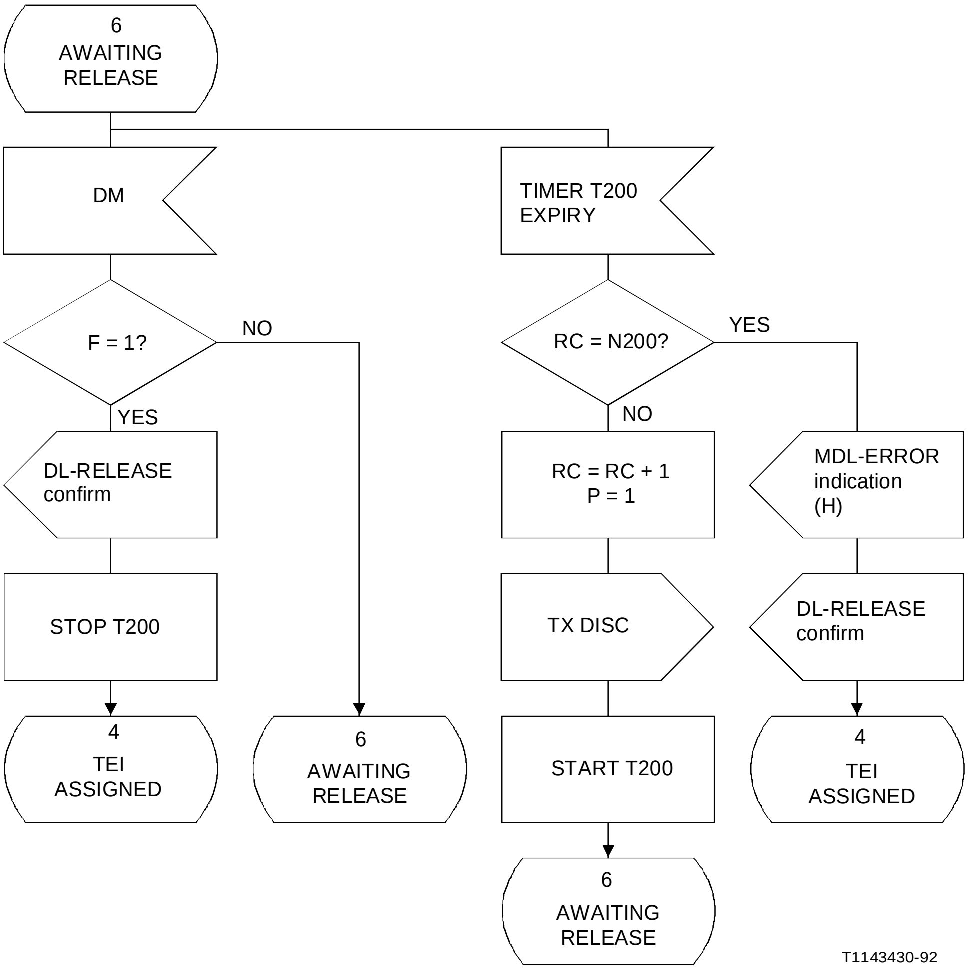



*Note 1* – Only possible in cases of layer 2 initiated re-establishment.
*Note 2* – This figure is unchanged from Recommendation Q.921 [2].



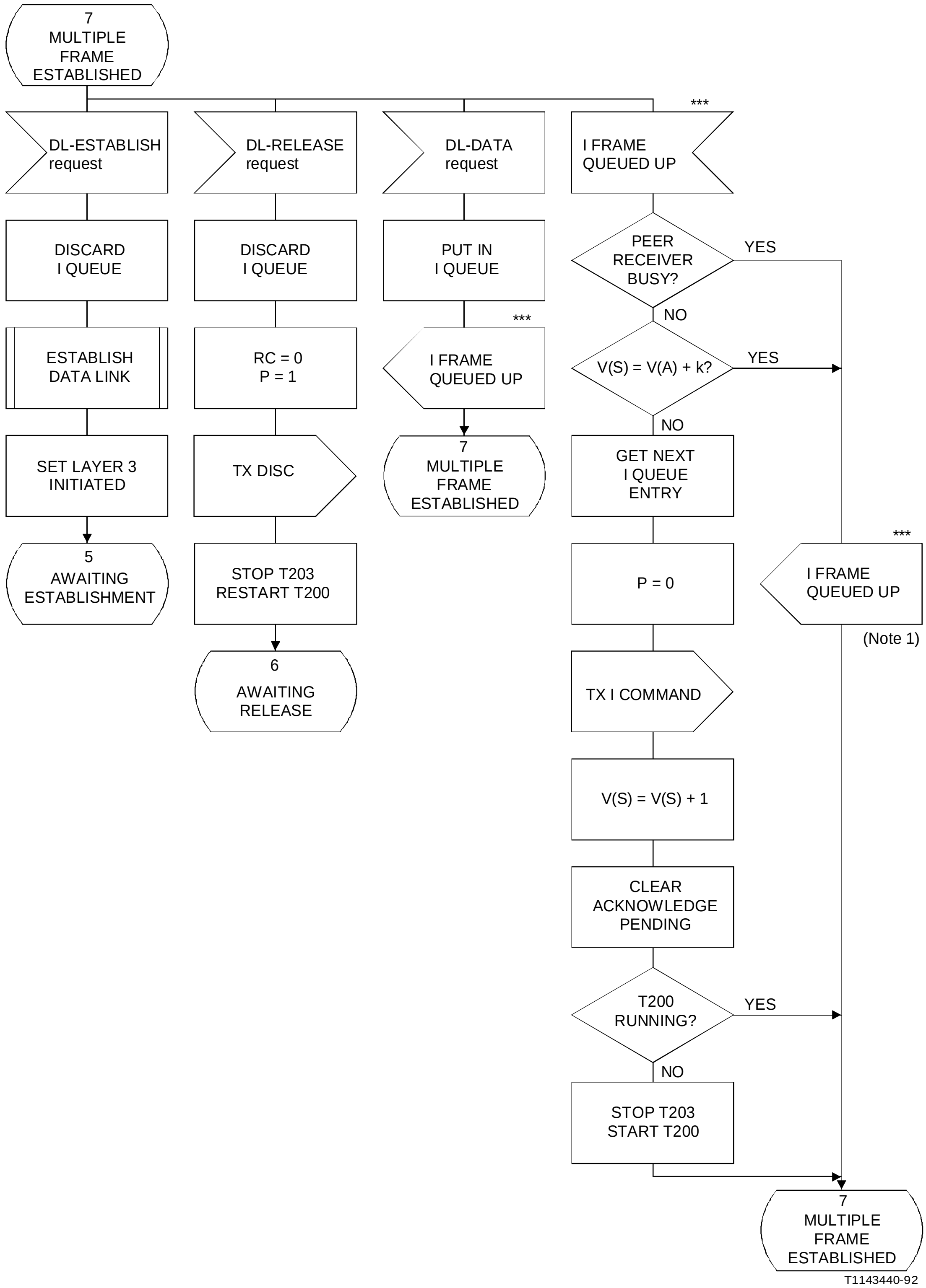

*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-6/Q.922 (sheet 1 of 2)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

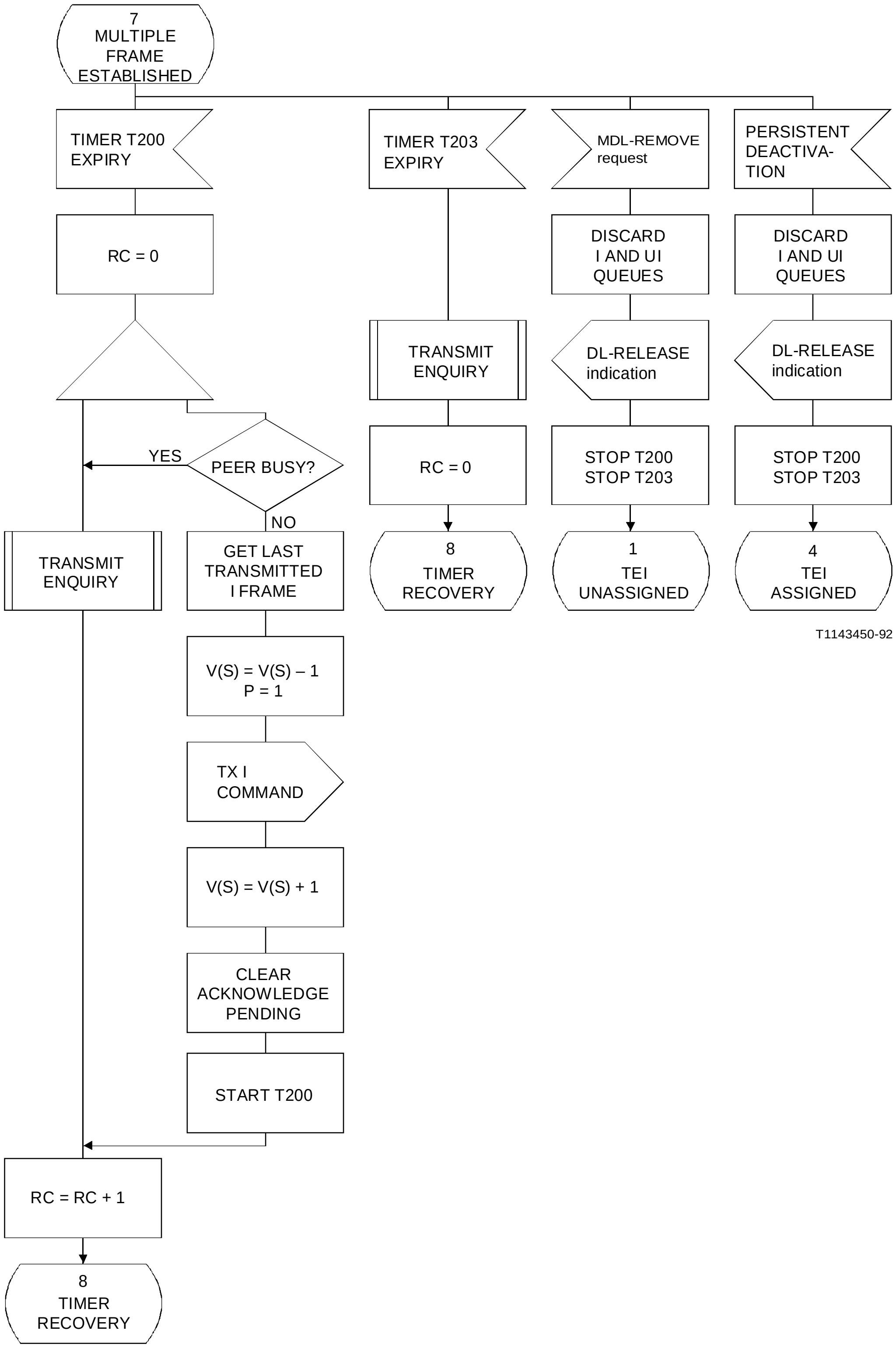
FIGURE B-6/Q.922 (sheet 2 of 2)




*Note 1* – The regeneration of this signal does not affect the sequence integrity of the I queue.

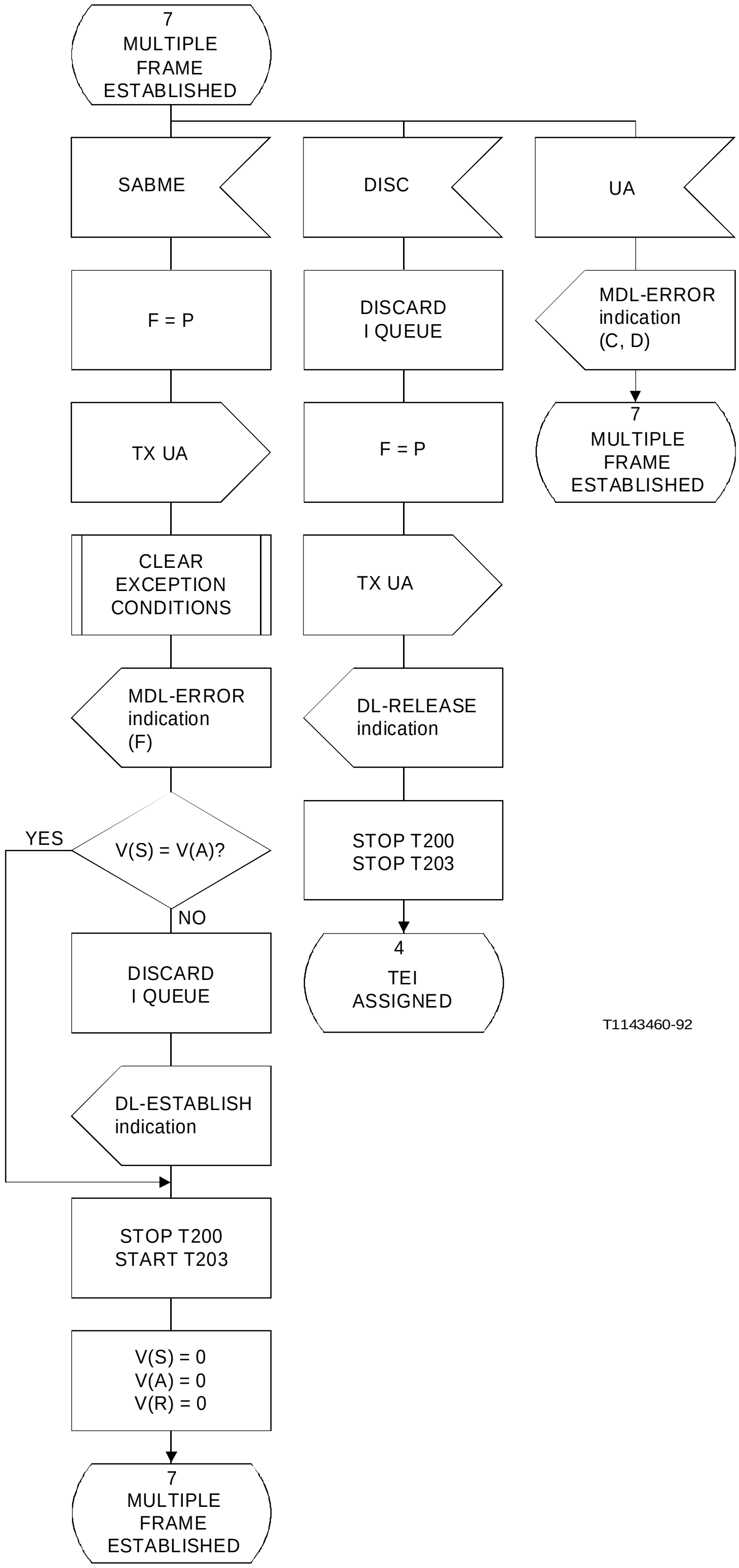
*Note 2* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 1 of 12)



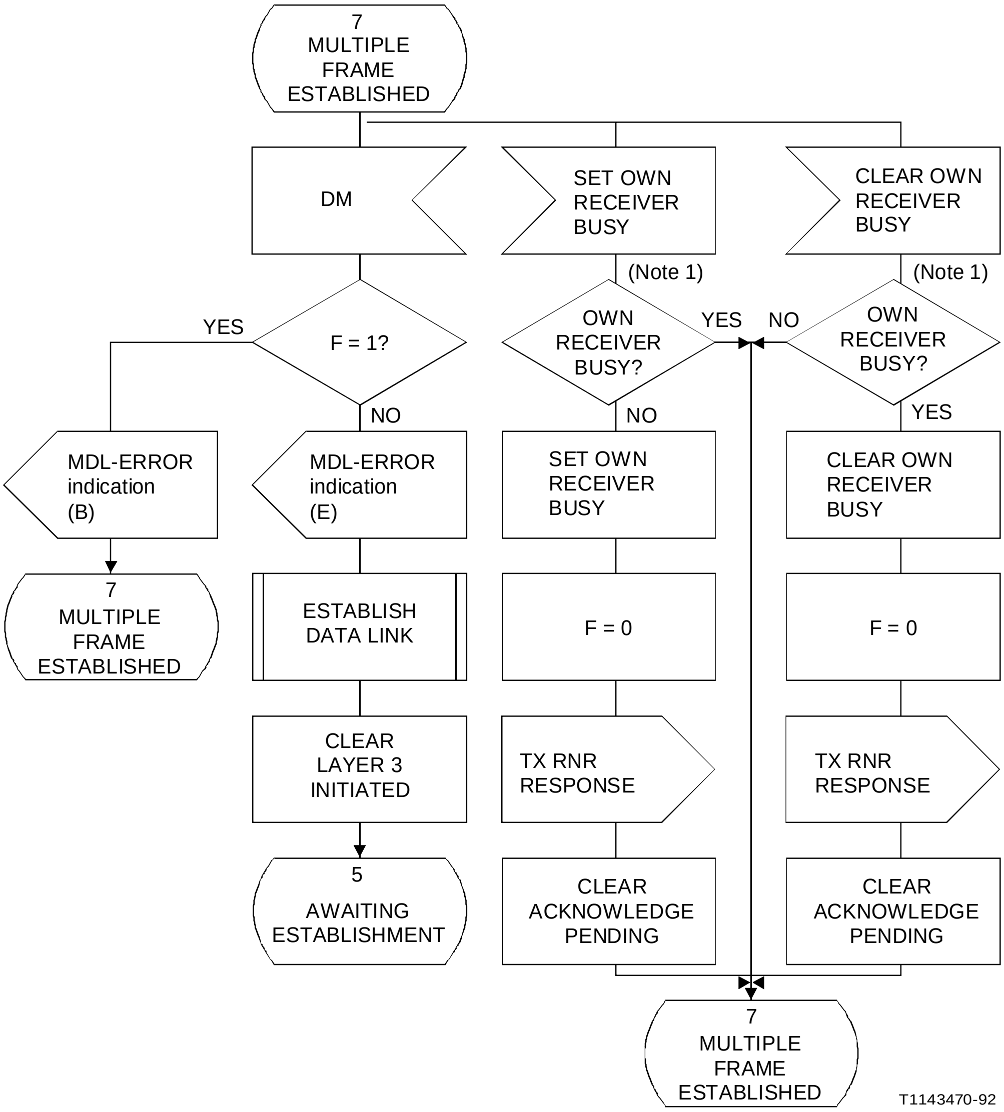

*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 2 of 12)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

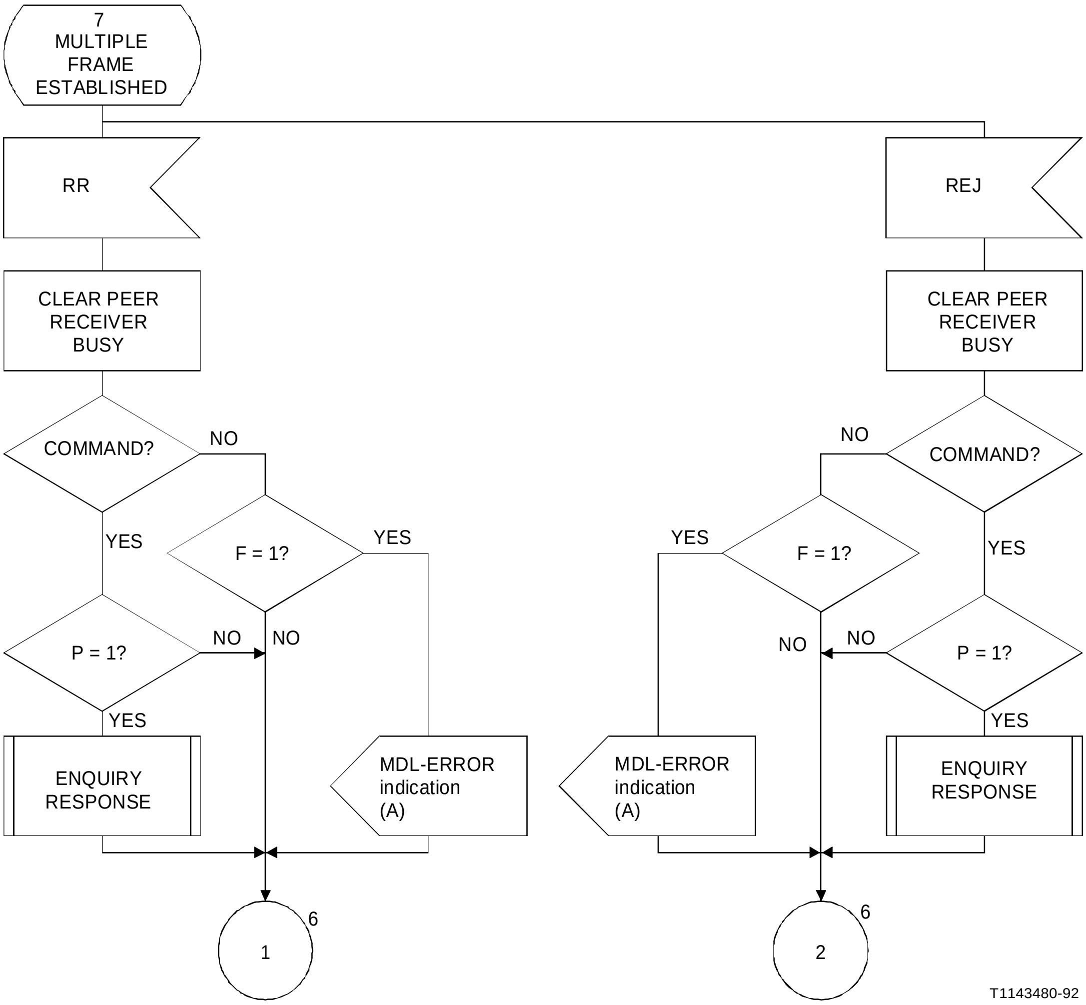
FIGURE B-7/Q.922 (sheet 3 of 12)




*Note 1* – These signals are generated outside of this SDL representation, and may be generated by the connection management entity.

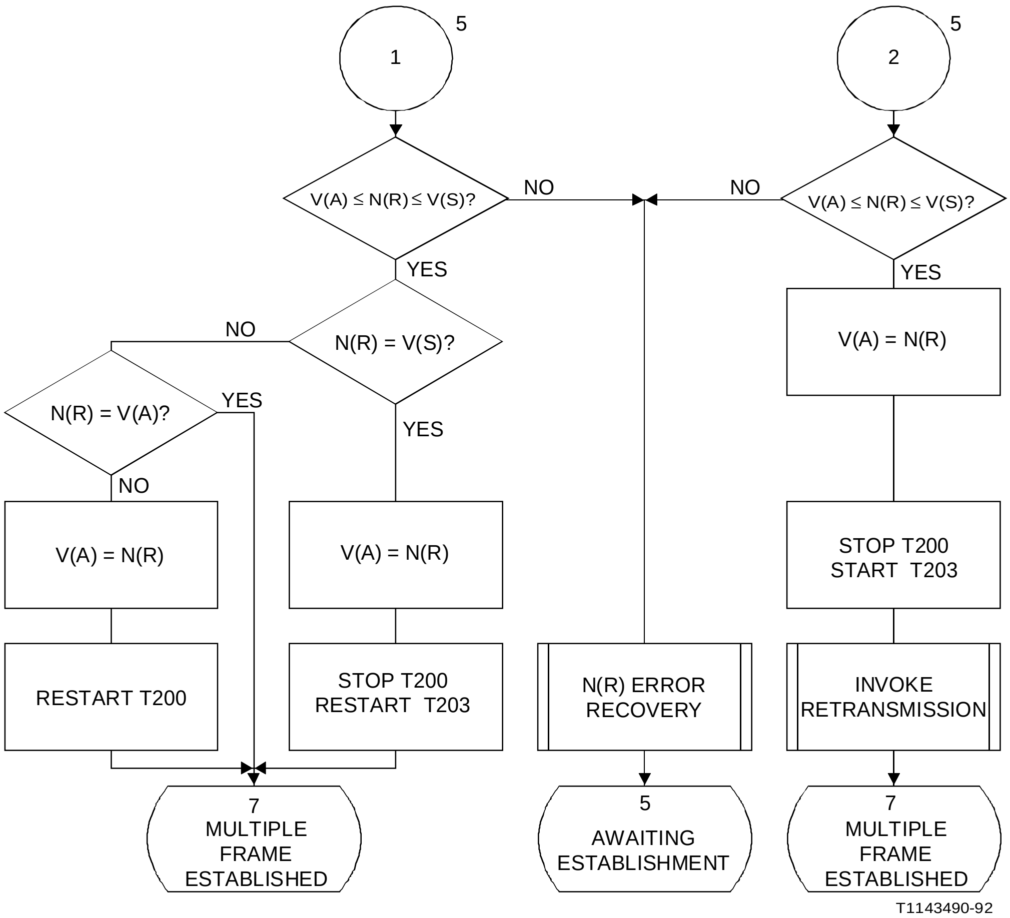
*Note 2* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 4 of 12)



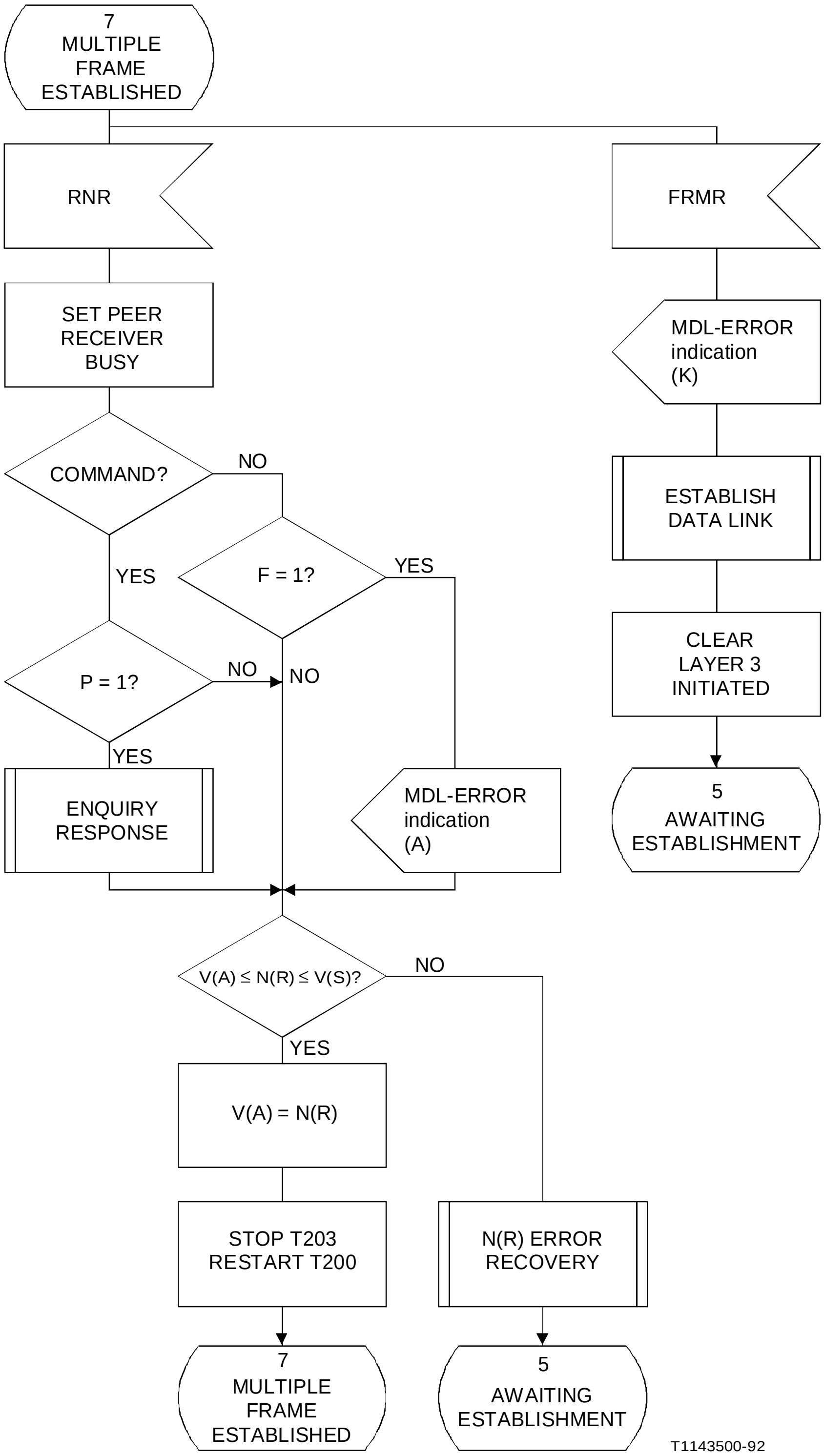

*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 5 of 12)



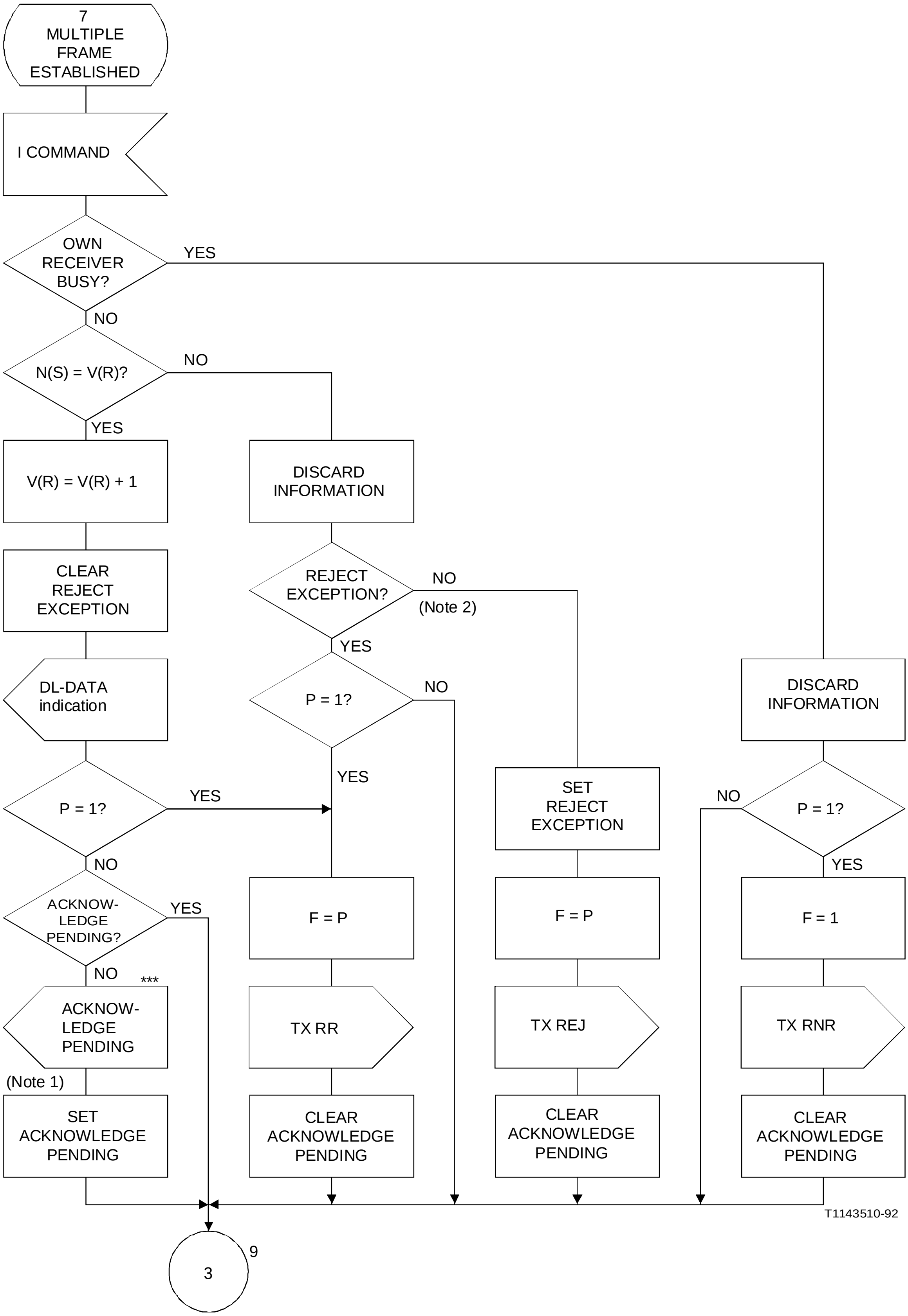

*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 6 of 12)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 7 of 12)

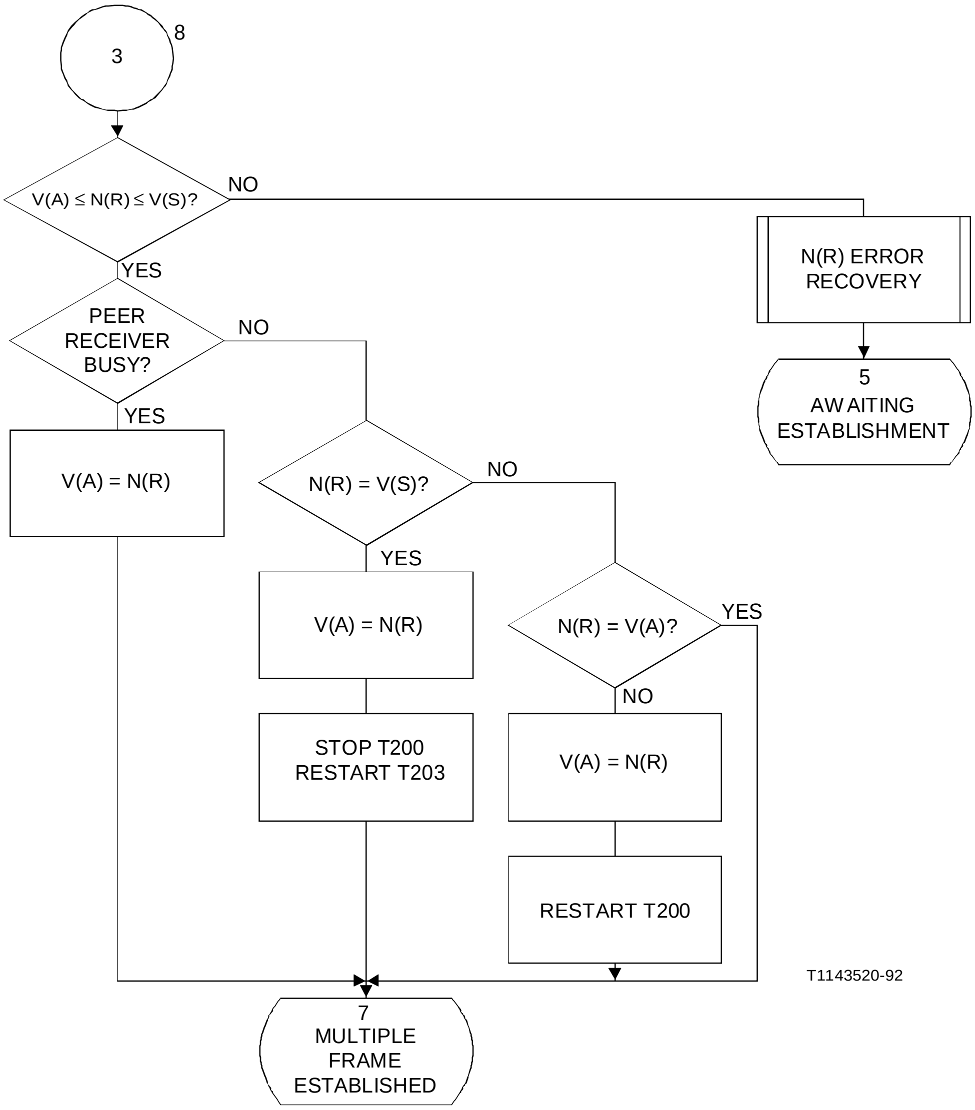



*Note 1* – Processing of acknowledge pending is described in Figure B-7/Q.922 (sheet 10 of 12).

*Note 2* – This SDL representation does not include the optional procedure in Appendix I of Recommendation Q.921 [2].

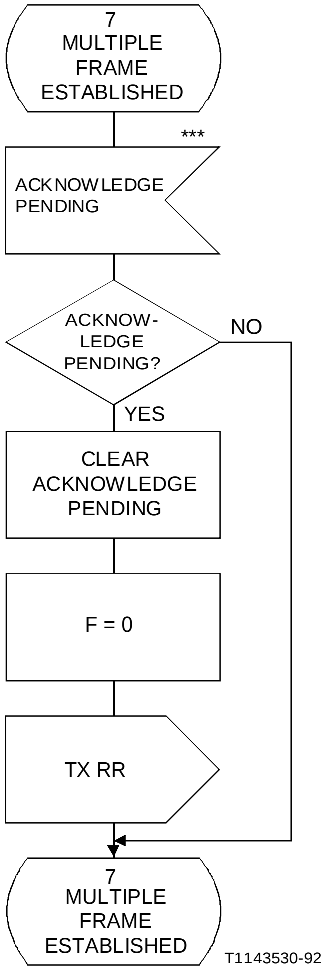
*Note 3* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 8 of 12)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 9 of 12)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-7/Q.922 (sheet 10 of 12)

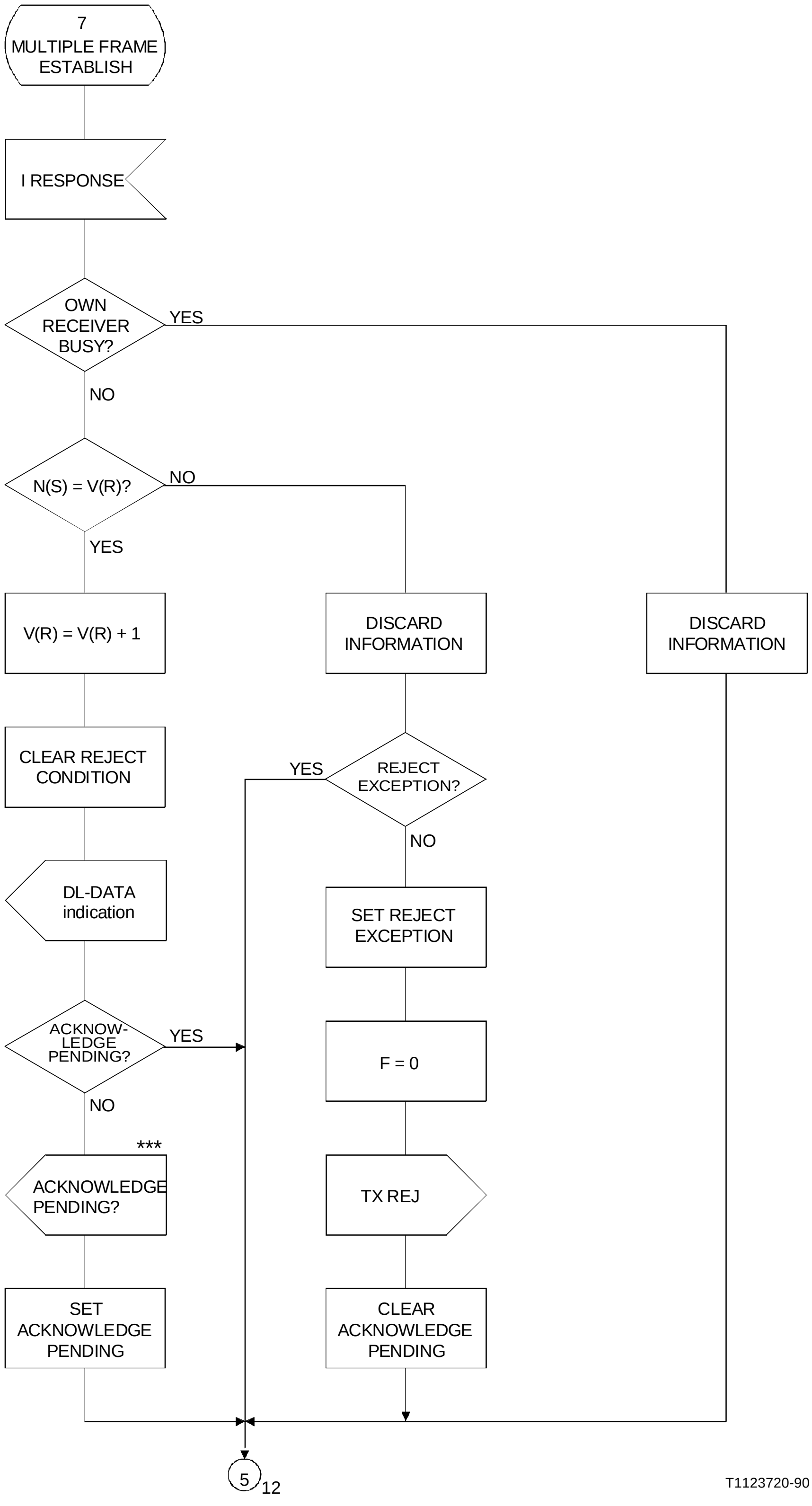



FIGURE B-7/Q.922 (sheet 11 of 12)

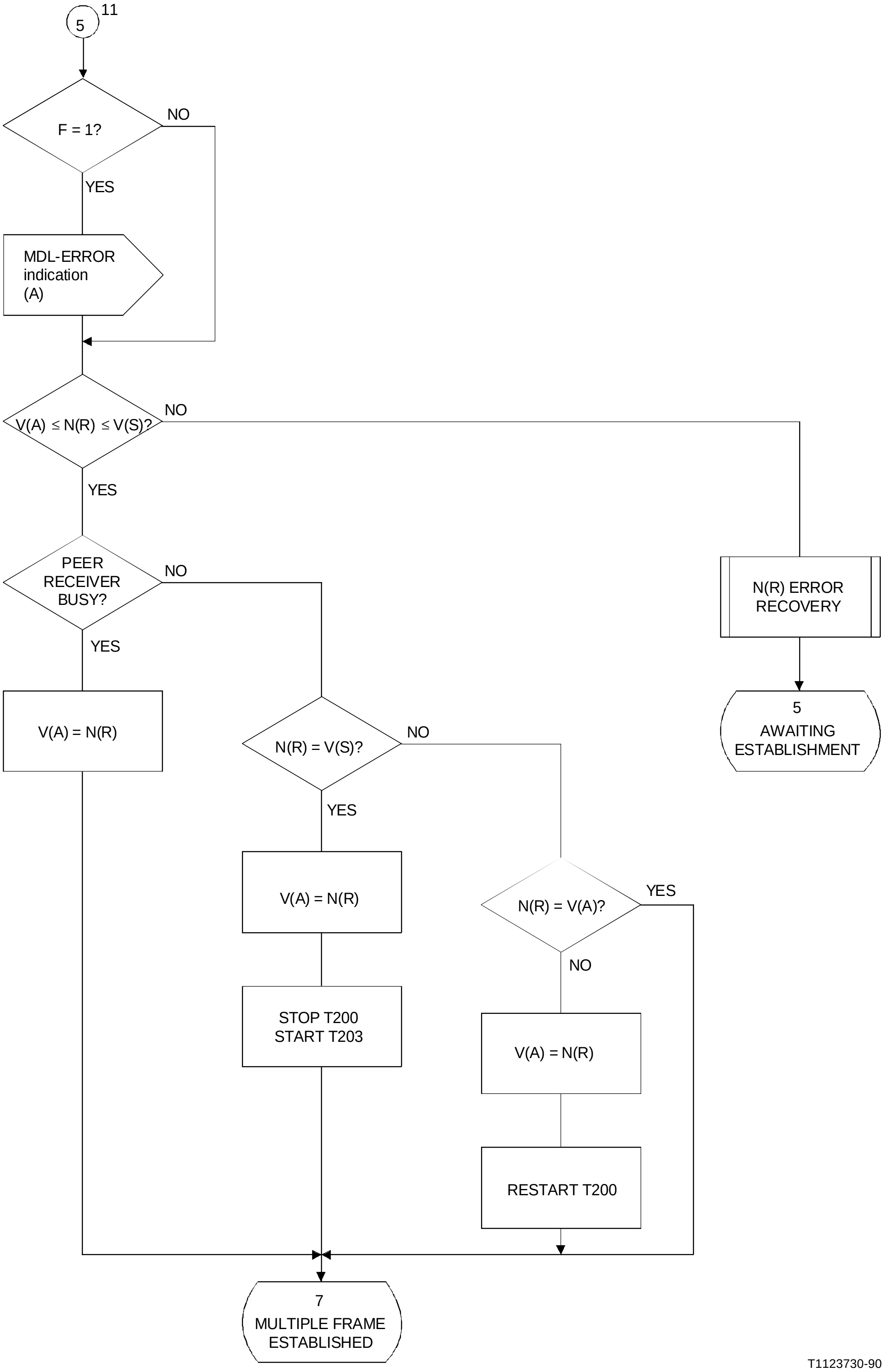
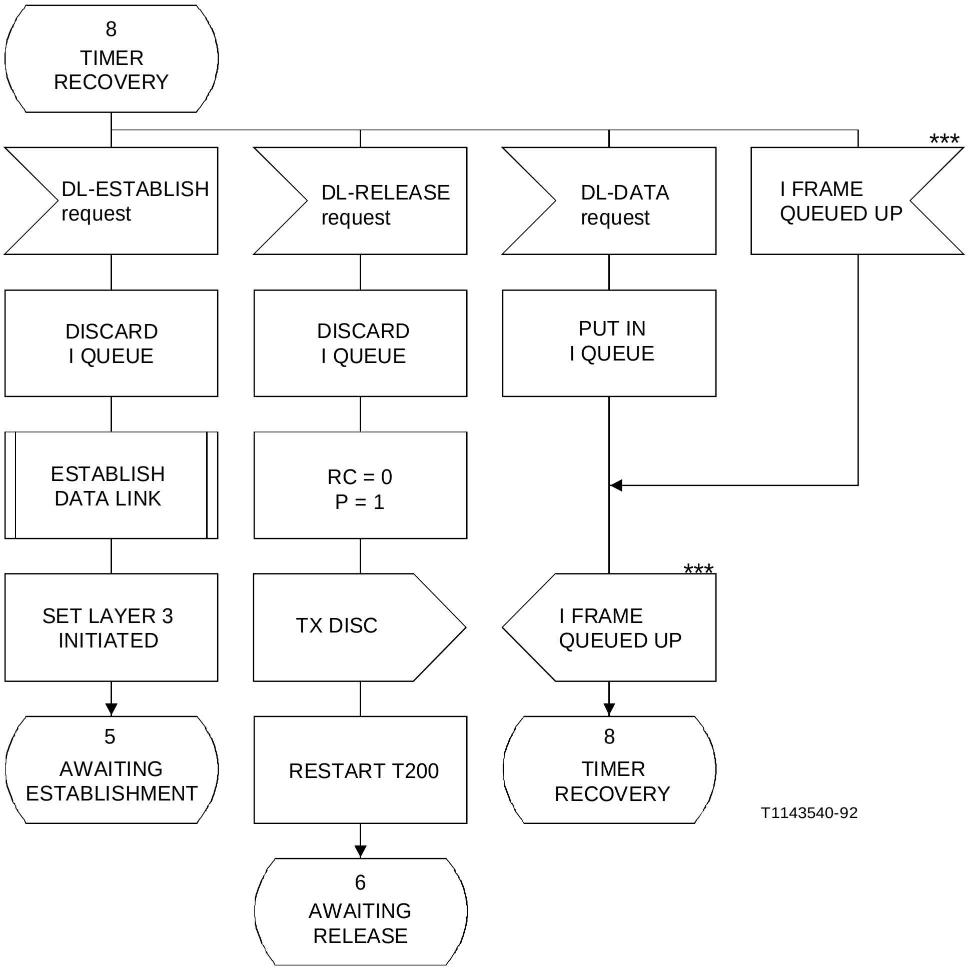
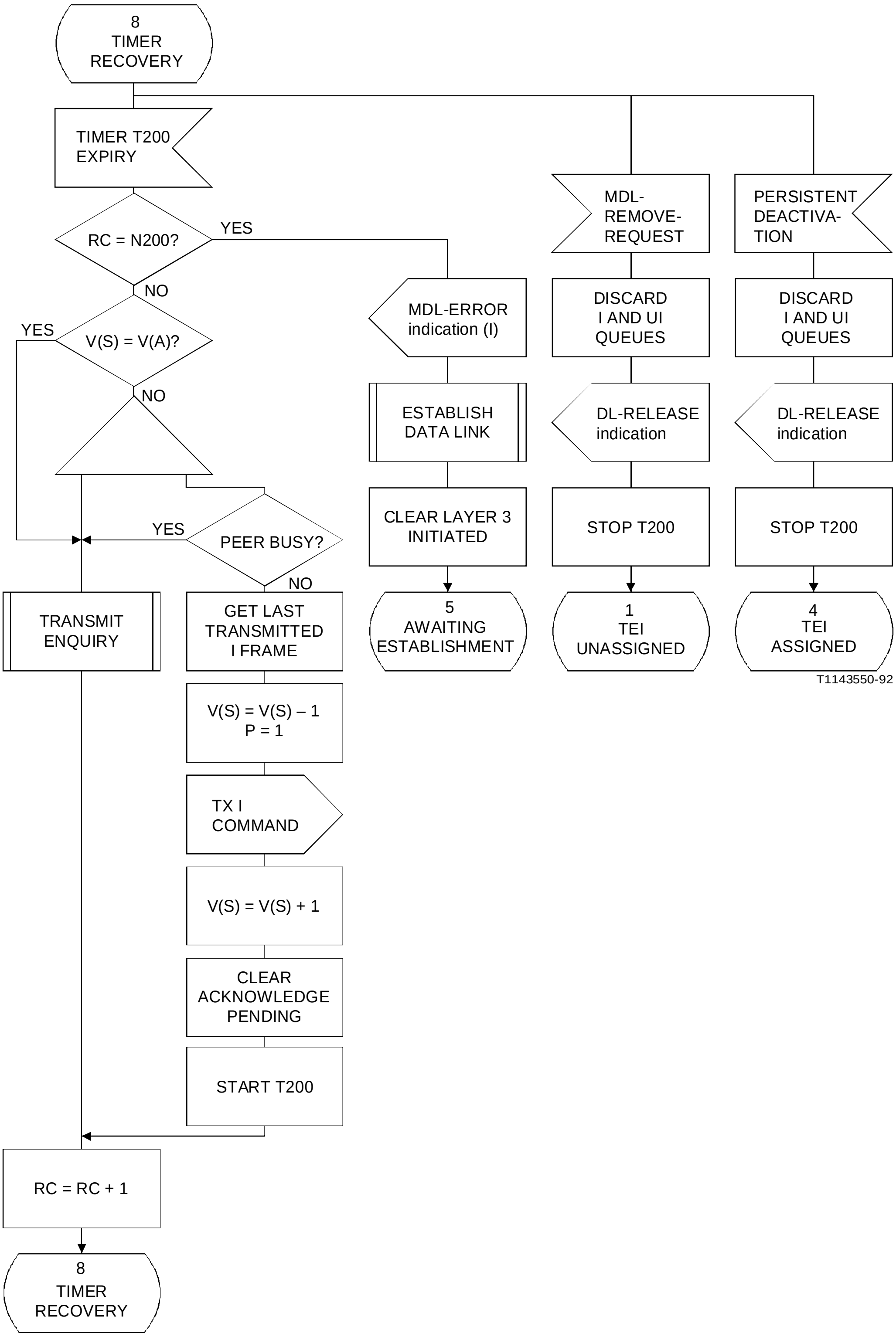



FIGURE B-7/Q.922 (sheet 12 of 12)



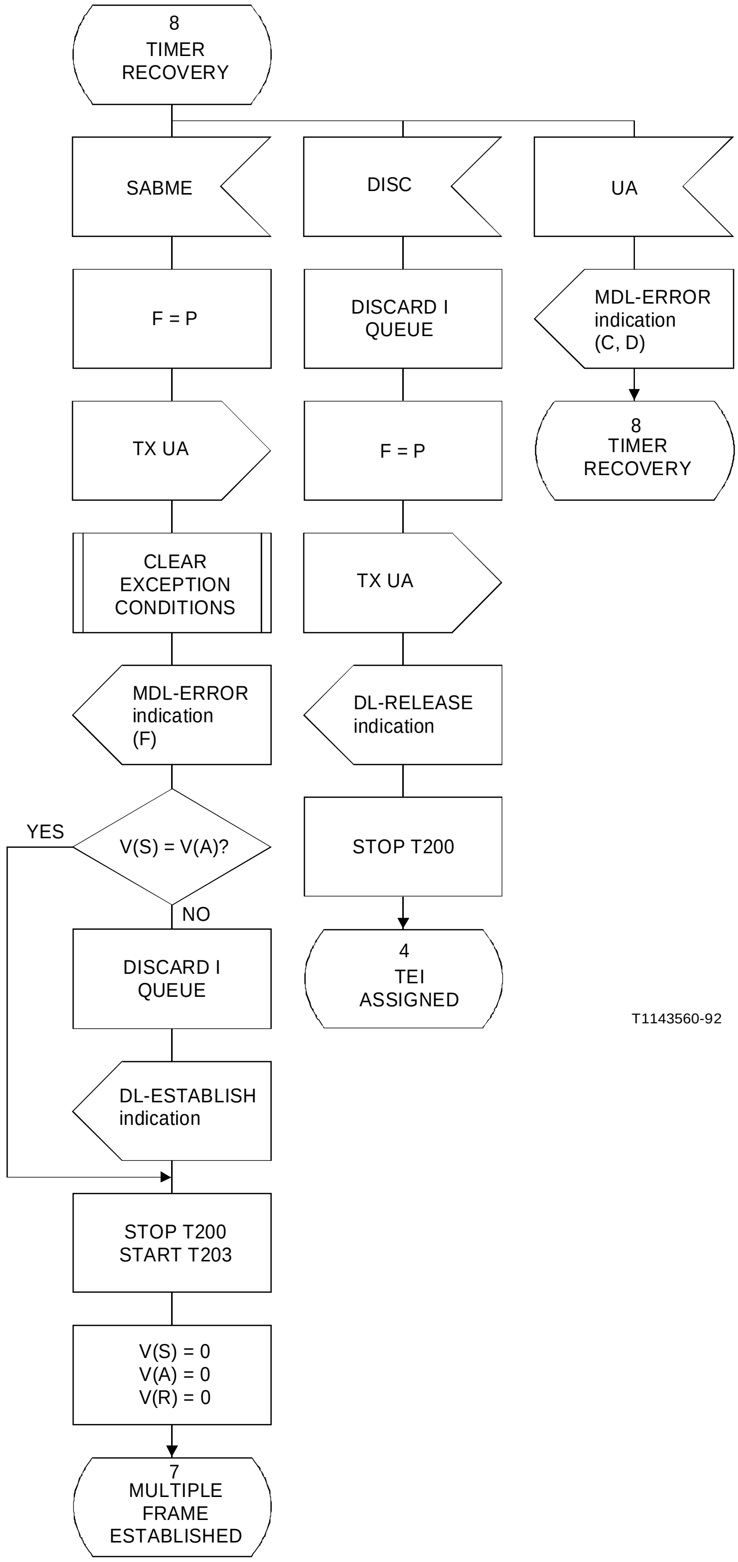

*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-8/Q.922 (sheet 1 of 11)



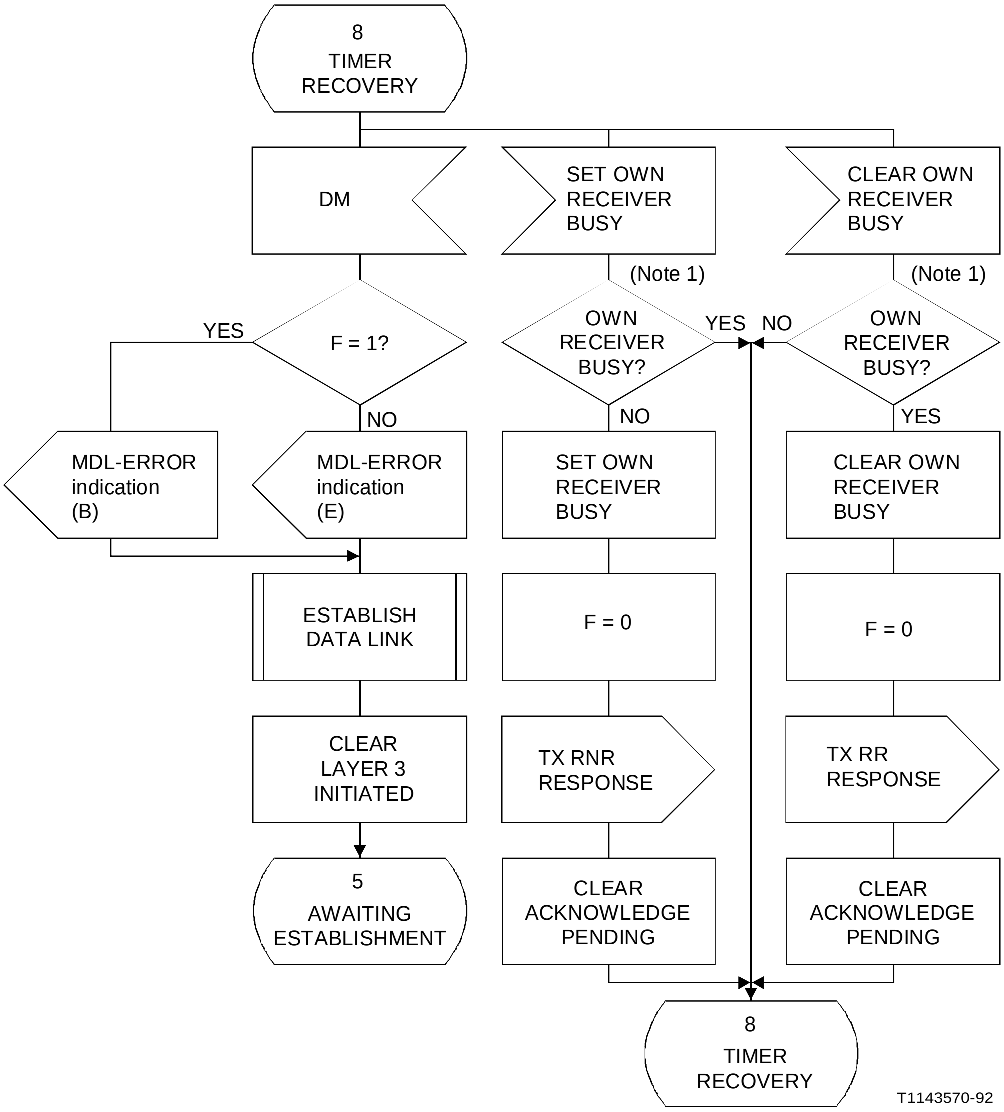

*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-8/Q.922 (sheet 2 of 11)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

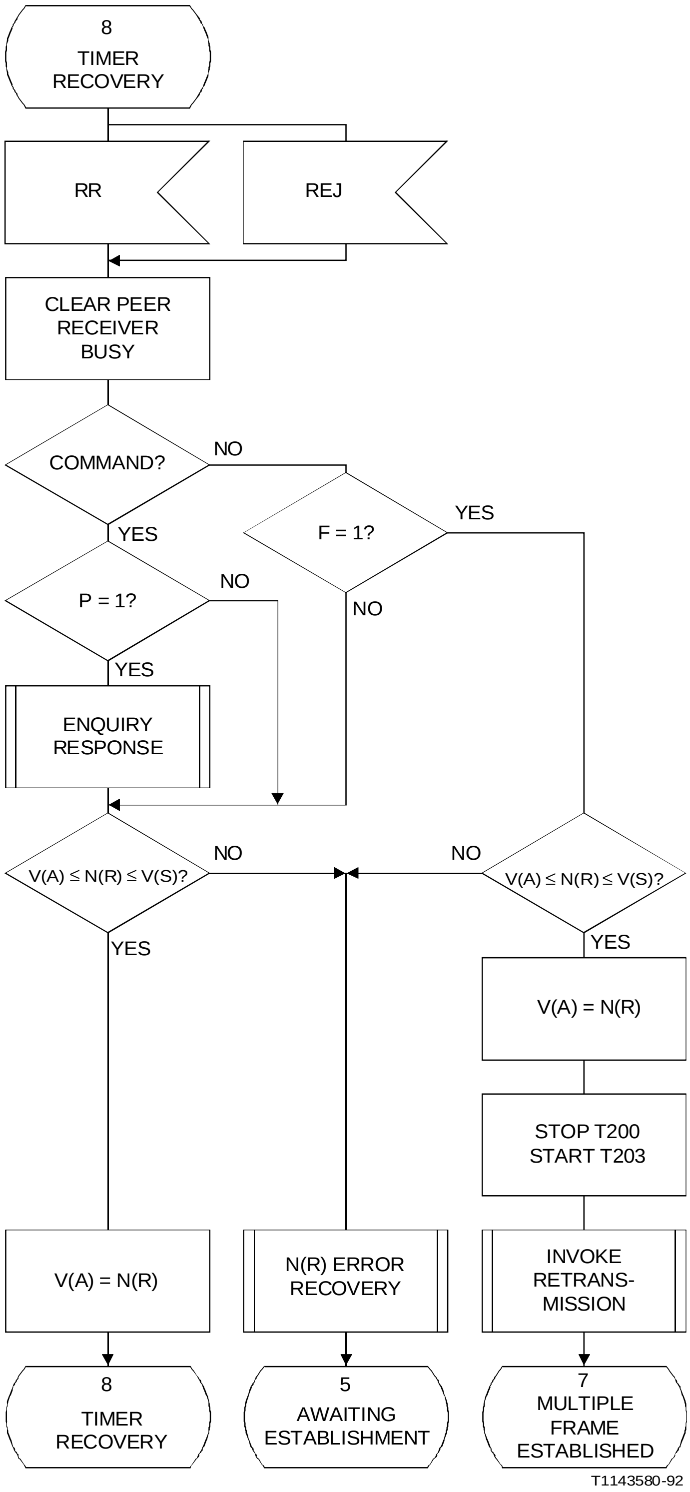
FIGURE B-8/Q.922 (sheet 3 of 11)




*Note 1* – These signals are generated outside of this SDL representation and may be generated by the connection management entity.

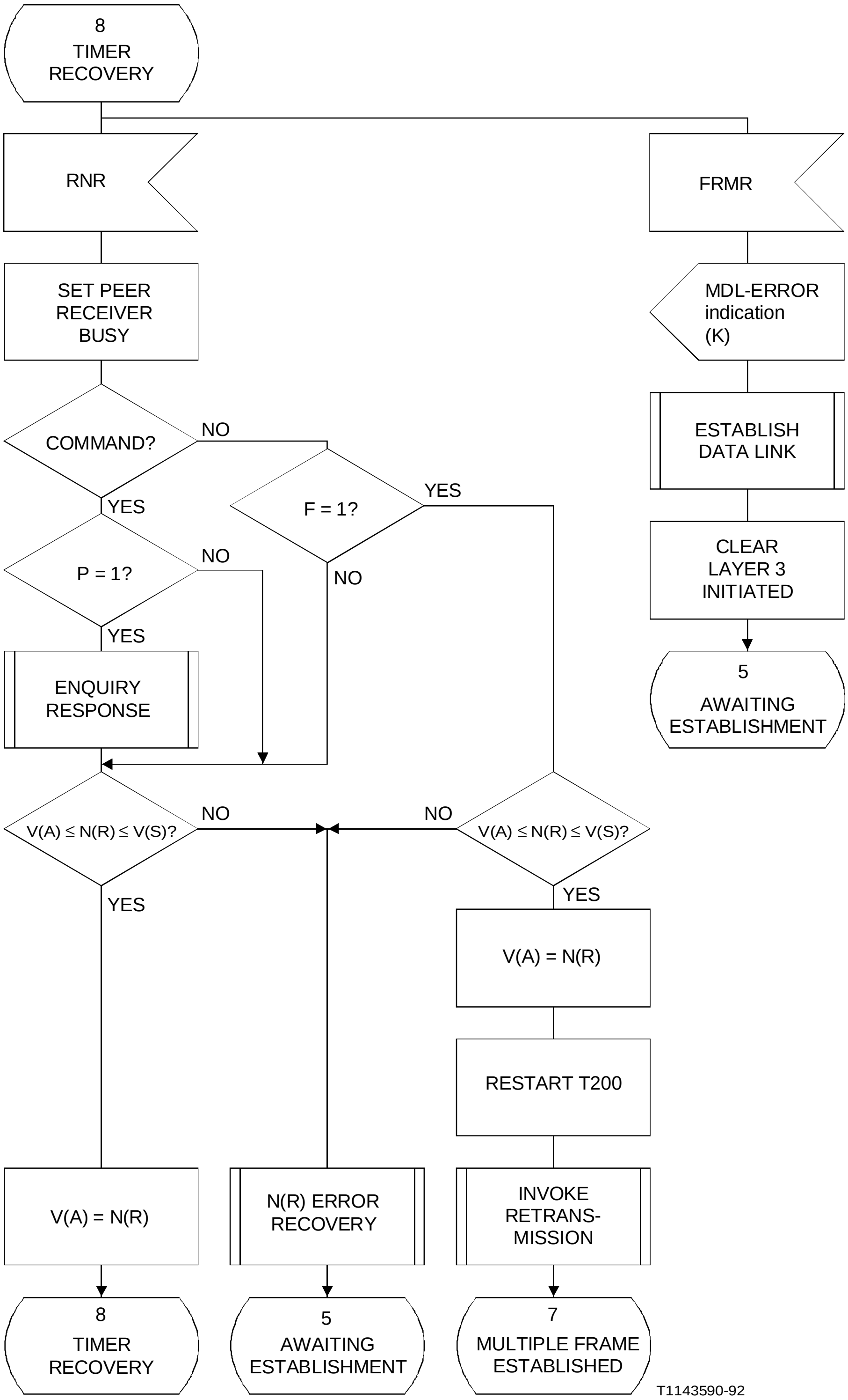
*Note 2* – This figure is unchanged from Recommendation Q.291 [2].

FIGURE B-8/Q.922 (sheet 4 of 11)



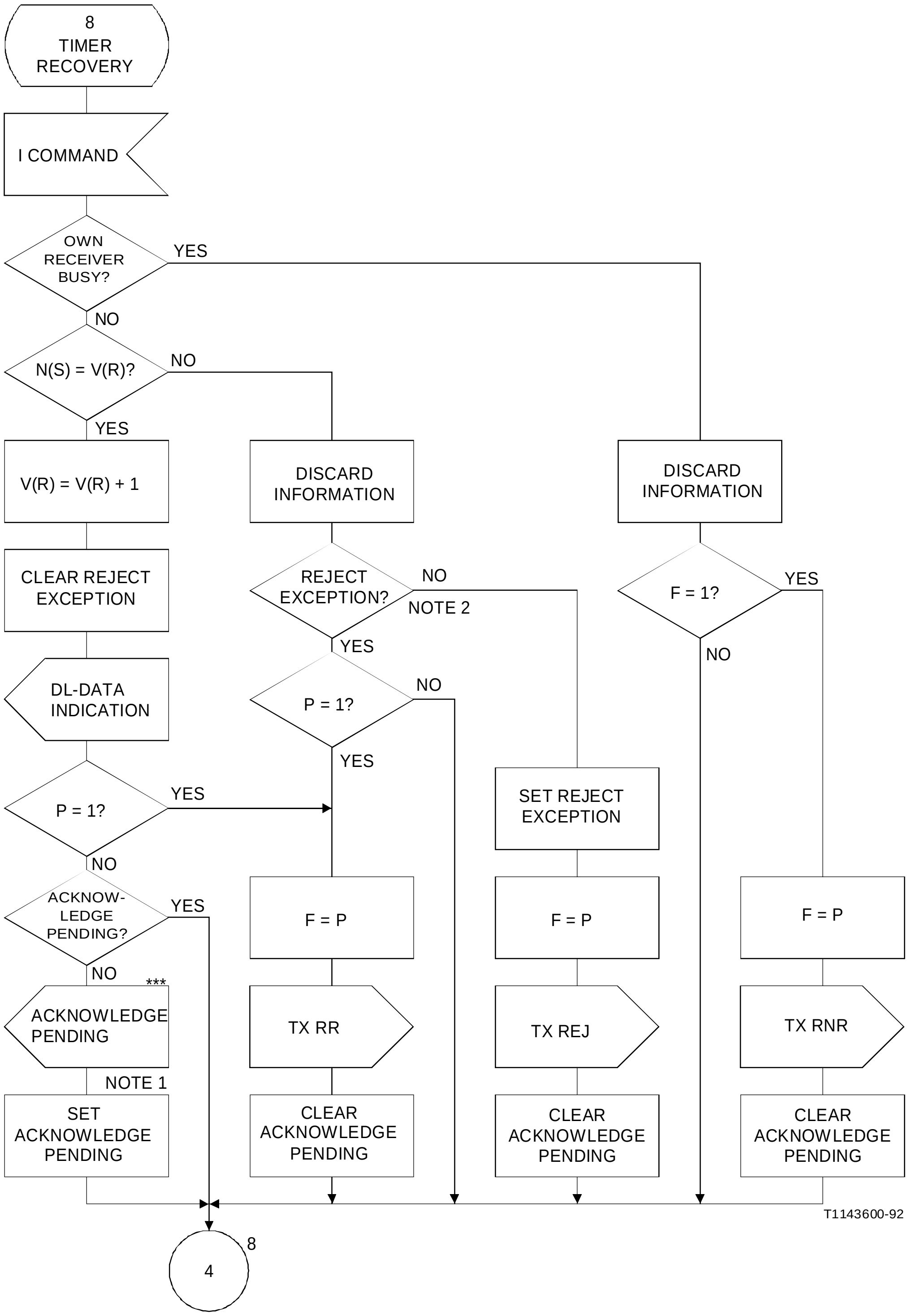

*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-8/Q.922 (sheet 5 of 11)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-8/Q.922 (sheet 6 of 11)

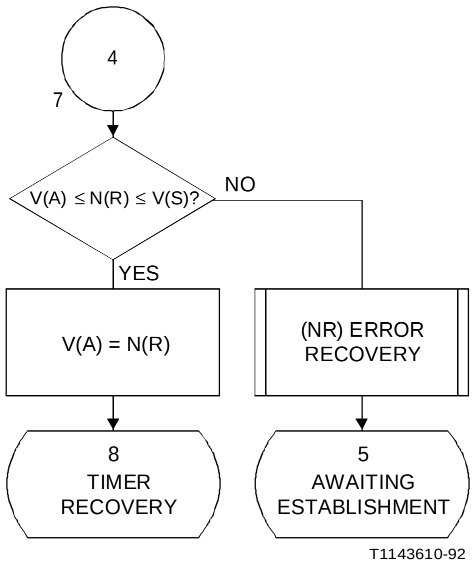



*Note 1* – Processing of acknowledge pending is described in Figure 8/Q.922 (9 of 11).

*Note 2* – This SDL representation does not include the optional procedure in Appendix I of Recommendation Q.921 [2].

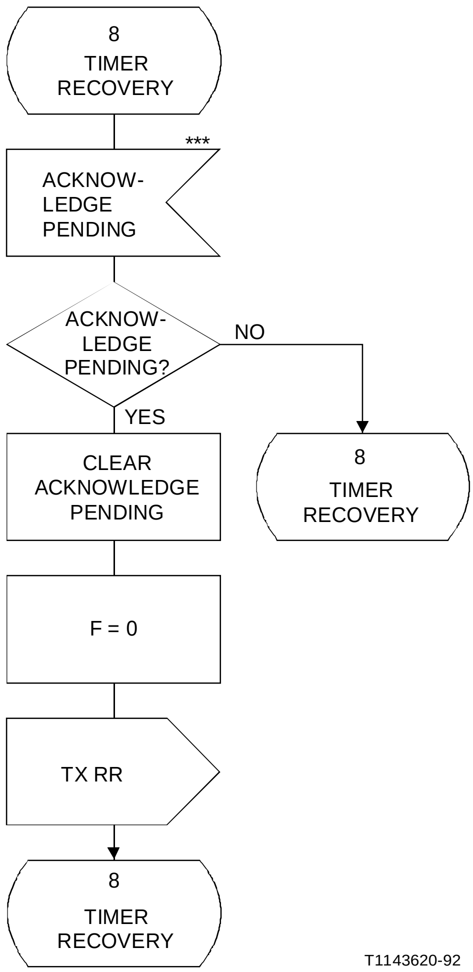
*Note 3* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-8/Q.922 (sheet 7 of 11)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-8/Q.922 (sheet 8 of 11)




*Note* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-8/Q.922 (sheet 9 of 11)

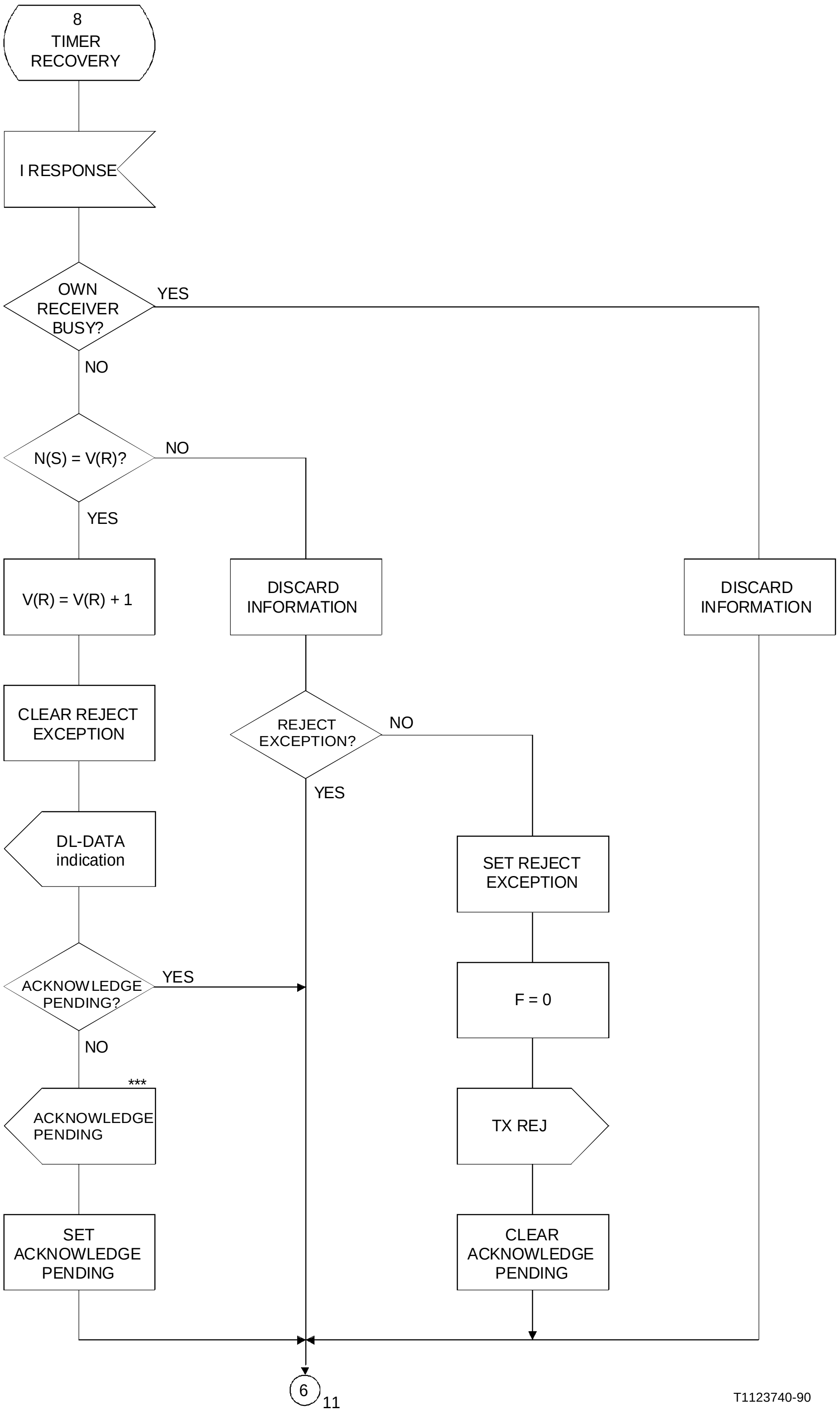
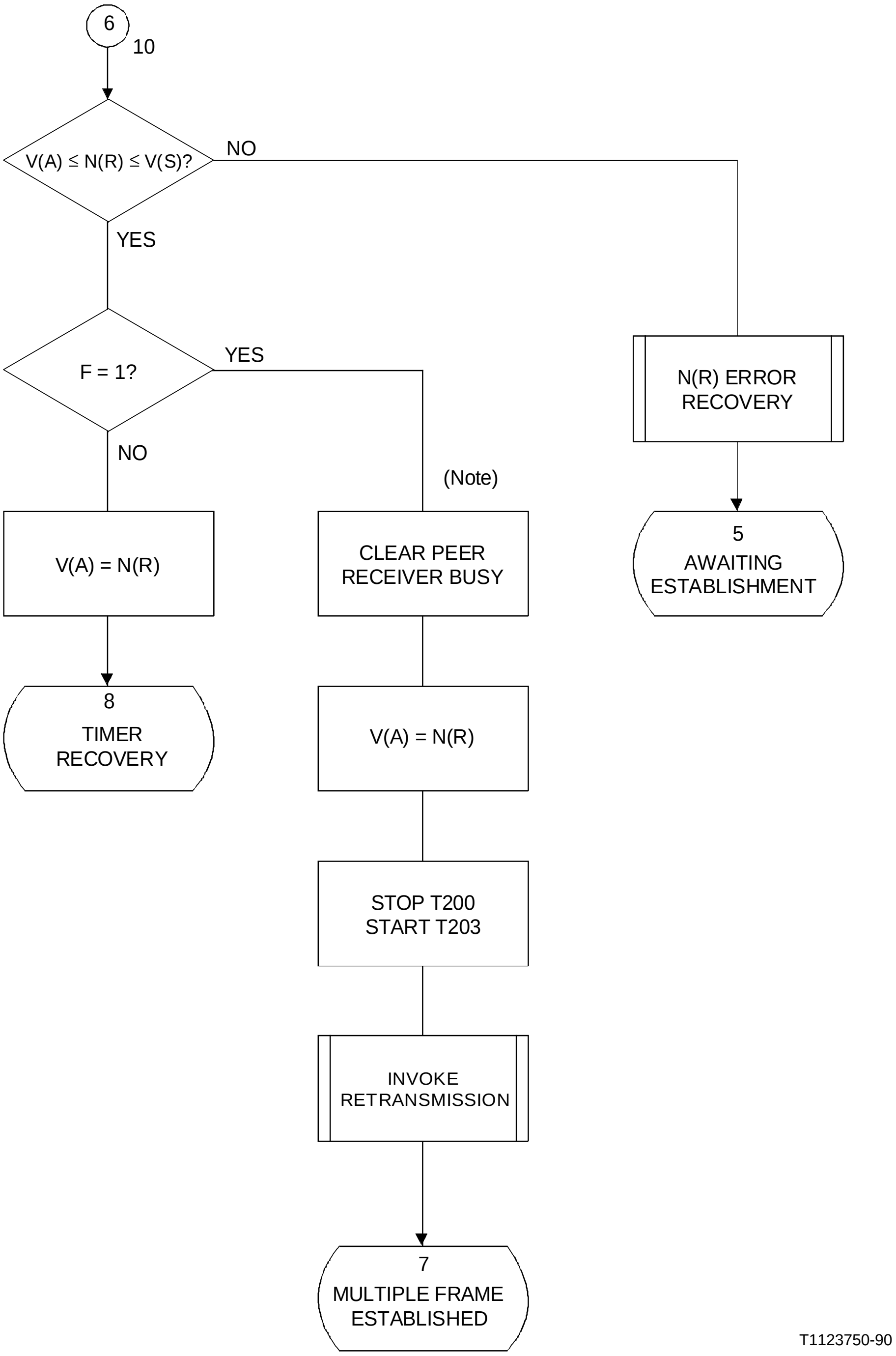
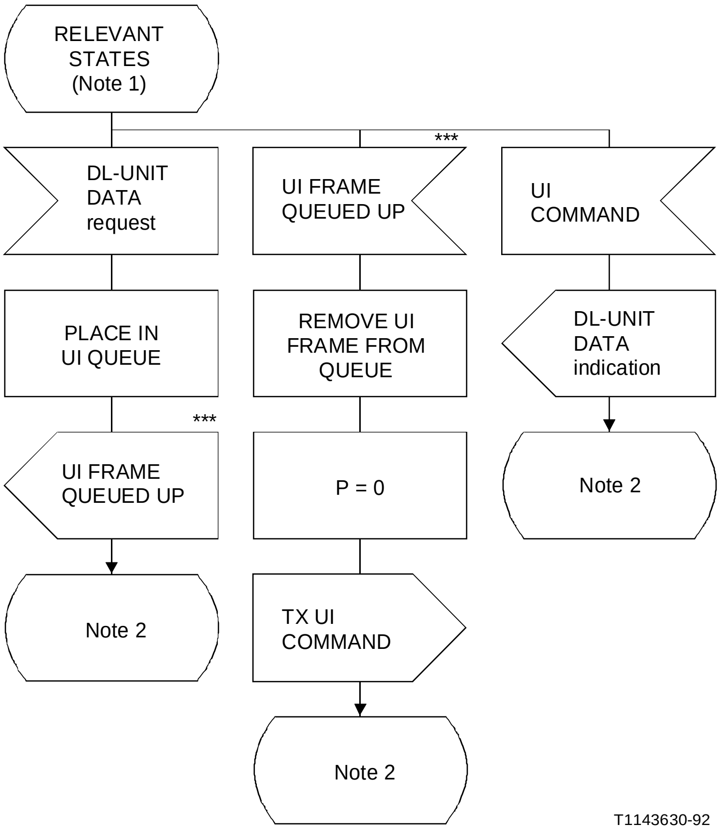



FIGURE B-8/Q.922 (sheet 10 of 11)




*Note* – If the peer receiver busy condition is to be maintained, the peer entity has to use an RNR response frame with the F-bit set to binary "1".

FIGURE B-8/Q.922 (sheet 11 of 11)



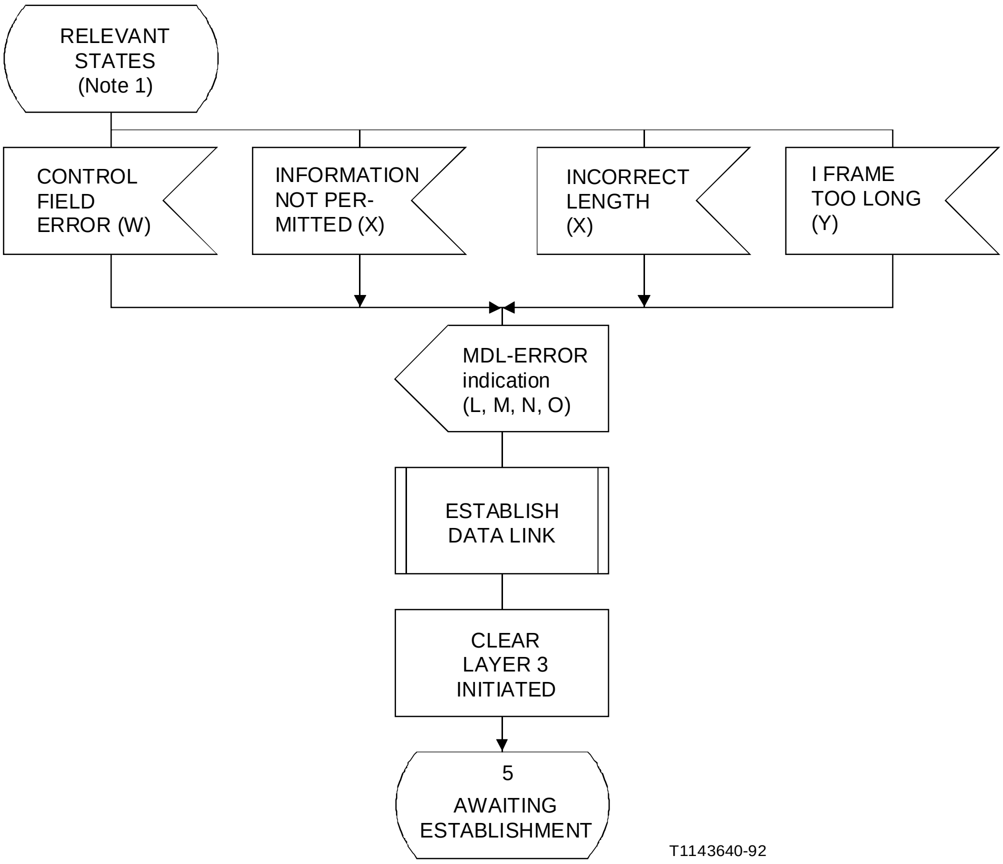

*Note 1* – The relevant states are:

4 TEI assigned
5 Awaiting establishment
6 Awaiting release
7 Multiple frame established
8 Timer recovery

*Note 2* – The data link layer returns to the state it was in prior to the events shown.

*Note 3* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-9/Q.922 (sheet 1 of 6)

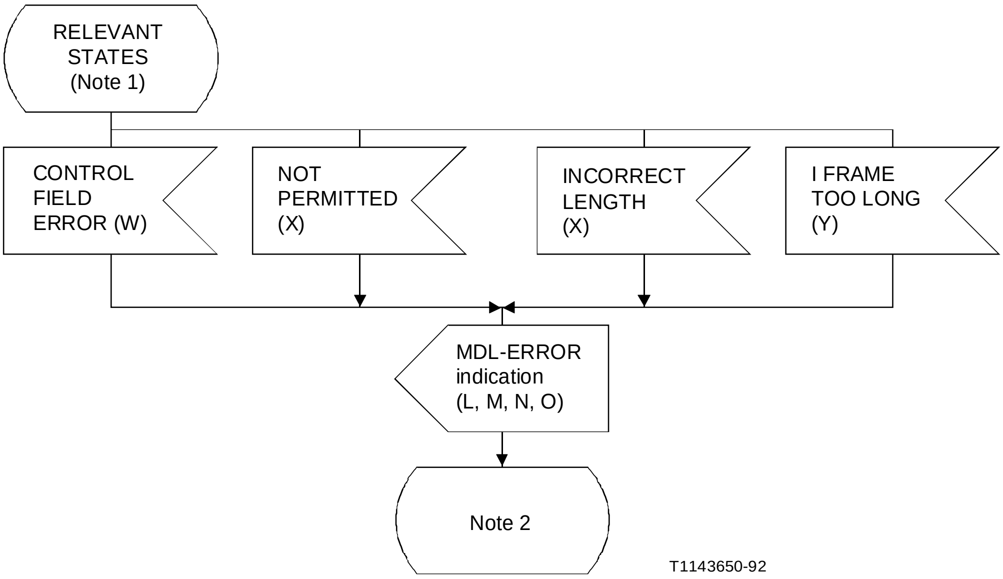



*Note 1* – The relevant states are:

7 Multiple frame established
8 Timer recovery

*Note 2* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-9/Q.922 (sheet 2 of 6)




*Note 1* – The relevant states are:

4 TEI assigned
5 Awaiting establishment
6 Awaiting release

*Note 2* – The data link layer returns to the state it was in prior to the events shown.

*Note 3* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-9/Q.922 (sheet 3 of 6)

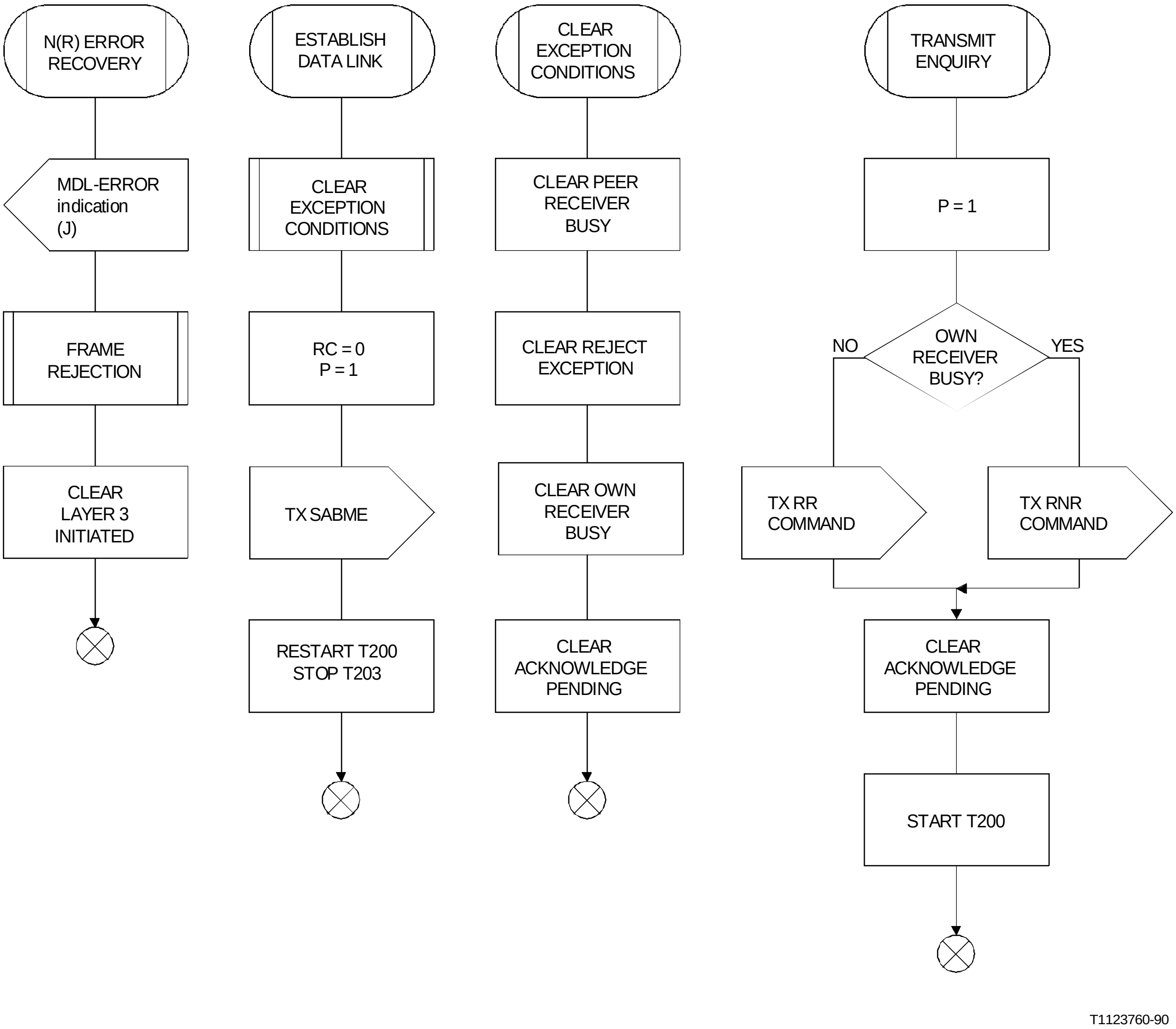
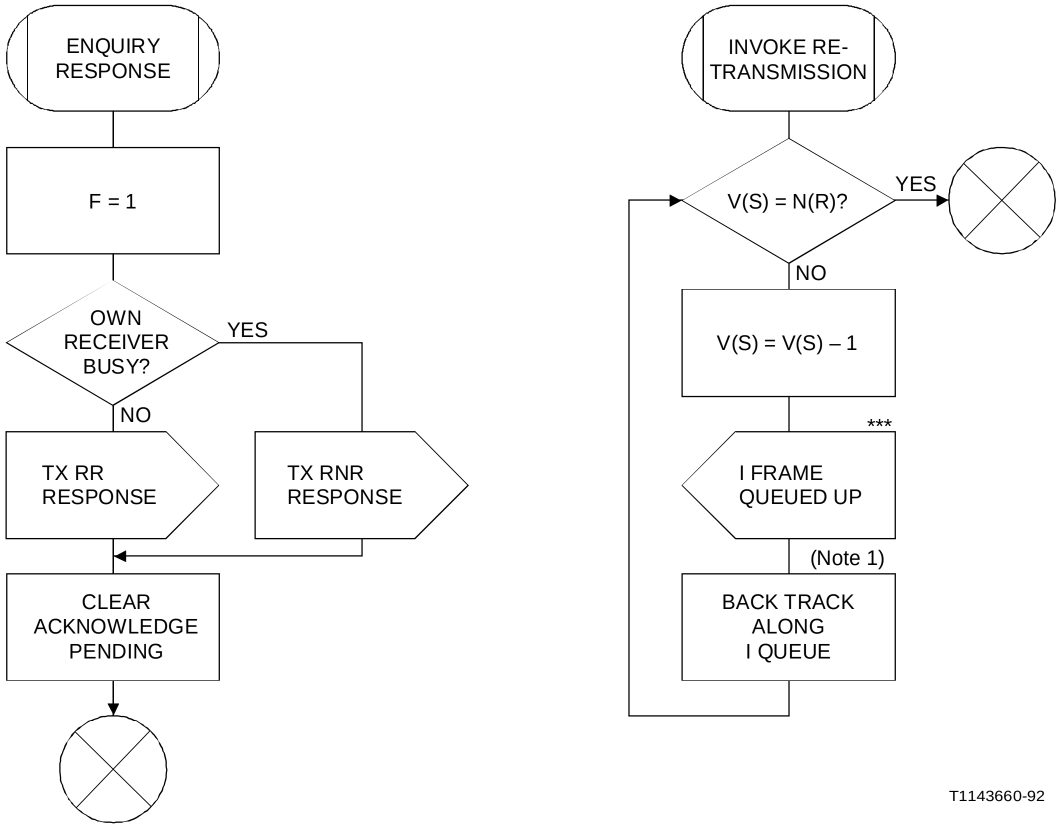



FIGURE B-9/Q.922 (sheet 4 of 6)




*Note 1* – The generation of the correct number of signals in order to cause the required retransmission of I frames does not alter their sequence integrity.

*Note 2* – This figure is unchanged from Recommendation Q.921 [2].

FIGURE B-9/Q.922 (sheet 5 of 6)

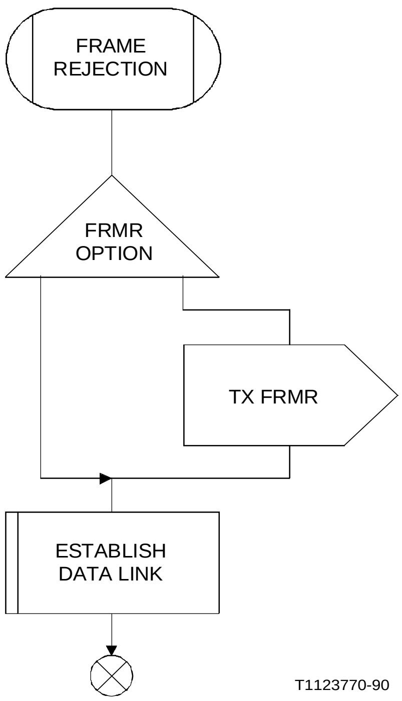



FIGURE B-9/Q.922 (sheet 6 of 6)

## APPENDIX I

(to Recommendation Q.922)

**Responses to network congestion**

### I.1 *Example use of dynamic window size to respond to implicit detection of network congestion*

The dynamic window algorithm is a way to control network congestion (circuit-switched connections between two end terminals have no need for this procedure). The algorithm modifies the transmitting data-link-layer entity's transmit window when congestion is first detected, and again as congestion decreases. The receiving data-link-layer entity does not participate in the algorithm and does not require knowledge of the sending data-link-layer entity's participation. Congestion in one direction of a link is treated independently of congestion in the other direction.

#### I.1.1 *Operation*

If a data-link-layer entity's transmit window parameter ($k$) is set to 1, the working window parameter $V(k)$ will always have the value 1 and the algorithm need not be invoked. If the data-link-layer entity's k is greater than 1, it uses a $V(k)$ equal to k in the absence of congestion.

This congestion control algorithm is triggered by the loss of I frames. A data-link-layer entity detects this loss:

– when it receives a REJ frame;

– when its T200 expires and it transmits a command with the P-bit set to 1, and subsequently receives an I-frame response or supervisory response in which the F-bit is set to 1, but in which the value of $N(R)$ is less than the current $V(S)$.

When a data-link-layer entity detects either of these events, it invokes the dynamic window algorithm, setting its $V(k)$ to a fraction (e.g. 0.25) of its previous value. $V(k)$, however, may not be reduced to a value to <1.

*Note* – This value is provided as part of an example. A higher value (e.g. 0.5) may be used, but might also lengthen the duration of the congestion event in the attempt to shorten the period needed to return to the throughput.

As I frames are then successfully transmitted and acknowledged, the transmit window size ($V(k)$ is gradually increased until it returns to $k$, its value in the absence of congestion. Several algorithms for control of the increase in $V(k)$ are possible. One possible scheme is described below.

The user may increase its working window by 1 after any window turn in which no further frame loss is detected. If the current working window is less than 8, the user may optionally increase it window size after receipt of five frames rather than waiting for an entire window turn.

*Note* – If the value of $k$ is large, the user may optionally increase its working window by a constant value greater than 1.

When $V(k)$ reaches its maximum value, $k$, the dynamic window algorithm ends.

A "slow start" mechanism is recommended, so as to cause convergence toward equilibrium on the connection. The initial rate should be set to the throughput or less, in order to avoid an impulse load on the network at the time the user begins transmitting. If the connection has been idle for a long period of time (e.g. on the order of tens of seconds) the offered rate should be returned to the throughput or less.

### I.1.2 *List of system parameters and variables*

In this algorithm, the following additional system parameters and variables are defined:

1) *Transmit working window (V(k))*

   The maximum number of sequentially numbered I frames that may be outstanding (that is, unacknowledged) at any given time. In the absence of congestion, $V(k)$ is equal to the maximum number of outstanding I frames ($k$). Initially, $V(k) = k$.

2) *Dynamic window step size ($N_w$)*

   The number ($N_w$) of I frames that must be successfully transmitted and acknowledged before the transmit working window is increased in the dynamic window algorithm is a system parameter. The default value is 5.

3) *Information acknowledge counter (Ia_Ct)*

   This counter contains the number of I frames successfully transmitted and acknowledged since the last adjustment of the transmit working window $V(k)$, in the dynamic window algorithm.

## I.2 *Sample algorithms for using FECN, BECN and CLLM*

This section contains an example for setting the forward and backward congestion indications (FECN, BECN, and CLLM) and examples of user reaction to these indications.

### I.2.1 *FECN usage*

#### I.2.1.1 *User behaviour on receipt of the FECN*

Users should compare the number of frames in which the FECN bit is set with the number of frames in which the FECN bit is cleared, over a measurement interval "δ". If the number of set FECN bits is equal to or exceeds the number of clear FECN bits received during this period, then the user shall reduce its current throughput to 7/8 (.875) of its previous value. If the number of set FECN bits is less than the number of clear FECN bits, then the user may increase its information rate by 1/16 of its throughput.

The suggested measurement interval "δ" is approximately equal to four times the end-to-end transit delay. Other mechanisms, not dependent on timers, may be used by the terminal if the effect is similar.

A "slow start" mechanism is recommended, so as to cause convergence toward equilibrium on the connection. The initial rate should be set to the throughput or less, in order to avoid an impulse load on the network at the time the user begins transmitting. If the connection has been idle for a long period of time (e.g. on the order of tens of seconds) the offered rate should be returned to the throughput or less.

##### I.2.1.1.1 *Use of windows as an approximation to rate based control*

For some implementations it may be convenient to use a window based mechanism as an approximation to rate based control. Such implementations may or may not be able to measure their offered rate or to relate it to the throughput negotiated with the network during connection establishment. The actual offered rate is limited by the end-to-end transit delay, access rate, window size and frame size.

*Note* – The use of window based mechanisms to approximate rate based control is reasonably accurate only if the statistical variance of the frame size is relatively small.

In the event that a windowed protocol is in use, then the user, in responding to the FECN, shall compare the number of frames received which have the FECN bit set with the number of frames received which have the FECN bit clear. The measurement interval for this shall be twice the interval during which the number of frames equal to the current window size is transmitted and acknowledged (i.e. two window turns). If the number of set FECN bits is equal to or exceeds the number of clear FECN bits received during this period, then the user shall reduce its working window size variable to 7/8 (.875) of its previous value; however, it never needs to reduce its working window below the size of one frame. If the number of set FECN bits is less than the number of clear FECN bits, then the user may increase its window size variable by the size of one frame, provided this does not exceed the maximum window size for that virtual circuit. After the adjustment is made, the set and clear FECN bit counters should be reset to zero and the comparison should begin again.

The working window should be initialized at a small value, such as one frame, to avoid an impulse load upon the network at the time that a user begins transmitting. If the connection has been idle for a long period of time (e.g. on the order of tens of seconds), it may be appropriate to again reduce the window size to its initial value. There may be a maximum window size of information rate that a connection is able to accommodate, as limited by the end system policies; the working window should not be adjusted beyond such a value.

*Note* – This algorithm is relatively insensitive to the loss of acknowledgements carried in the user data when they are used to carry window adjustment information back to the source.

I.2.1.2 *Recommended behaviour of the FECN bit user in response to implicit notification*

If the user has the capability to determine that a frame has been lost, reaction should be implemented to this loss. This should be regarded as complementary to (rather than mutually exclusive from) explicit congestion notification.

Upon determining that a frame has been dropped, the user should reduce its offered rate to 0.25 times the previous value.

*Note* – This value is provided as part of an example. A higher value (e.g. 0.5) may be used, but might also lengthen the duration of the congestion event in the attempt to shorten the period needed to return to the throughput.

If the network is known to be providing explicit congestion notification and no frames received during the measurement interval "δ" were received with the FECN bit set, there is a moderate likelihood that the frame loss is due to transmission error and not to congestion. In such cases, the offered throughput should be reduced to 0.625 times its previous value.

The user may increase its throughput by a factor of 0.125 after any measurement interval in which no further frame loss is detected. Once this throughput rate reaches 0.5 times the value in use when the initial frame loss was detected, this increase factor should change to 0.625. These increase factors may be limited by the increase factors specified in § I.2.1.1 for explicit congestion notification.

I.2.1.2.1 *Use of windows as an approximation to rate based control*

Users may use a window based mechanism as an approximation to rate based control.

Upon determining that a frame has been dropped, the user should reduce its current working window size to the greater of 0.25 times the previous value or 1.

If the network is known to be providing explicit congestion notification and no frames received during the prior window turn were received with the FECN bit set, there is a moderate likelihood that the frame loss is due to transmission error and not to congestion. In such cases, the working window size should be reduced to the greater of 0.625 times its previous value or 1.

The user may increase its working window size by 1 after any window turn in which no further frame loss is detected. If the current working window size is less than 8, the user may optionally increase its window size after receipt of five frames, rather than waiting for an entire window turn. These increase factors may be limited by the increase factors specified in § I.2.1.1 for explicit congestion notification.

I.2.1.3 *Network use of the FECN bit*

The FECN bit may be set by any entity within the network that detects a state of imminent congestion. The condition for setting this bit is a network option, with the following procedure being illustrative.

The frame relay switching system monitors the size of each queue in the system. Determination of imminent congestion is a function of network design and is not subject to standardization.

I.2.1.3.1 *Example implementation of imminent congestion determination*

This section describes one possible method that networks are able to use to determine if congestion is imminent. It is included to illustrate the concept of imminent congestion and to demonstrate the role of the network in the operation of the feedback loop using the FECN bit. Other implementations may yield similar or improved results.

A regeneration cycle begins when the outgoing circuit goes from idle (queue empty) to busy (non-zero queue size, including the current frame). During the period between the start of the previous regeneration cycle and the present time within the present cycle, the average size of the queue is computed. If the average size of the queue exceeds a threshold value, then the circuit is in a state of imminent congestion. Beginning at that time, and continuing until the average queue size falls below the threshold, the FECN bit shall be set on all outgoing frames.

The average queue length may be computed as follows:

$$\text{Ave queue length} = (\text{queue size} \times \text{time interval}) / (\text{duration of previous and current cycles}) \qquad \text{(I-1)}$$

I.2.2 *BECN usage*

I.2.2.1 *Recommended behaviour of user in response to explicit congestion notification*

I.2.2.1.1 *Use of rate based control*

For use with the BECN mechanism, a step count, $S$, is defined. $S$ is used to determine when the transmitter may increase or decrease its rate, based on the state of the BECN bits received. If the user expects the number of frames received to be approximately equal to the number transmitted (e.g. if a protocol like LAPD, which requires immediate acknowledgement of I frames, is used), the ratio of the backward frame rate to forward frame rate ($F_b/F_f$) will equal 1.

$$S = (F_b/F_f)\ [(IR_f)\ (TD)/N202_f + (IR_b)\ (TD)/N202_b] \text{(I-2)}$$

where:

$$IR_f = (Th_f/8) + [Be_f/(Be_f + Bc_f)]\ (AR_f/8) \qquad \text{(I-3)}$$

$$IR_b = (Th_b/8) + [Be_b/(Be_b + Bc_b)]\ (AR_b/8) \qquad \text{(I-4)}$$

| | |
|---|---|
| $S$ | Step function count |
| $Th_f$ | Throughput in the forward direction |
| $Th_b$ | Throughput in the backward direction |
| $TD$ | End-to-end transit delay |
| $N202_f$ | Maximum information field length in the forward direction |
| $N202_b$ | Maximum information field length in the backward direction |
| $AR_f$ | Access rate forward |
| $AR_b$ | Access rate backward |
| $Be_f$ | Excess burst size forward |
| $Be_b$ | Excess burst size backward |
| $Bc_f$ | Committed burst size forward |
| $Bc_b$ | Committed burst size backward |
| $F_b/F_f$ | Ratio (either expected or measured over some implementation dependent period of time) of frames received to frames sent. |

If a frame with a BECN bit set to “1” is received, and the user’s offered rate is greater than throughput, the user should reduce its offered rate to the throughput agreed for the frame relay connection.

If *S* consecutive frames are received with the BECN bit set, the user should reduce its rate to the next “step” rate below the offered rate. Further rate reduction should not occur until an additional *S* consecutive frames are received with the BECN bit set. The “step” rates are:

$0.675 \times$ throughput

$0.5 \times$ throughput

$0.25 \times$ throughput.

*Note* – User perception of network quality of service will be enhanced if the network is engineered such that reduction below 0.5 times throughput never becomes necessary. Networks may take alternative action (e.g. rerouting) to prevent such an occurrence.

When the user has reduced its rate due to receipt of BECN, it may increase its rate by a factor of 0.125 after any *S*/2 consecutive frames are received with the BECN bit clear.

A “slow start” mechanism is recommended, so as to cause convergence toward equilibrium on the connection. The initial rate should be set to the throughput or less, in order to avoid an impulse load on the network at the time the user begins transmitting. If the connection has been idle for a long period of time (e.g. on the order of tens of seconds) the offered rate should be returned to the throughput or less.

#### I.2.2.1.2 *Use of windows as an approximation to rate based control*

For some implementations it may be convenient to use a window based mechanism as an approximation to rate based control. Such implementations may or may not be able to measure their offered rate or to relate it to the throughput negotiated with the network during connection establishment. The actual offered rate is limited by the end-to-end transit delay, access rate, window size and frame size.

For use with the BECN, a step count, *S*, is defined. *S* is used to determine when the transmitter may increase or should decrease its rate, based on the state of the congestion bits. For approximation by use of windows, S is defined as an interval during which one frame is transmitted and acknowledged (i.e. one window turn).

If a frame with a BECN bit set to “1” is received, the user should reduce its working window size to 0.625 times the previous value. If *S* consecutive frames are subsequently received with the BECN bit set, this reduction should be repeated. However, the window size should never be reduced to less than one.

The user may increase its working window size by one frame after any *S*/2 consecutive frames are received with the BECN bit clear, provided this does not exceed the maximum window size.

A “slow start” mechanism is recommended, to improve the rate of convergence to equilibrium on the connection. The initial working window should be a small value (e.g., $0.5 \times$ last working window size) to avoid an impulse load on the network at the time the user begins transmitting. If the connection has been idle for a long period of time (e.g., on the order of tens of seconds) the window size should be set to its initial value.

*Note* – The use of window based mechanisms to approximate rate based control is reasonably accurate only if the statistical variance of the frame size is relatively small.

### I.2.2.2 *BECN user response to implicit congestion indication*

#### I.2.2.2.1 *Use of rate based control*

If the user has the capability to determine that a frame has been lost, reaction should be implemented to this loss. This should be regarded as complimentary to (rather than mutually exclusive from) explicit congestion notification.

Upon determining that a frame has been dropped, the user should reduce its offered rate to 0.25 times the previous value.

*Note* – This value is provided as part of an example. A higher value (e.g. 0.5) may be used, but might also lengthen the duration of the congestion event in the attempt to shorten the period needed to return to the throughput.

If the network is known to be providing explicit congestion notification and no frames received during the measurement interval "δ" were received with the BECN bit set, there is a moderate likelihood that the frame loss is due to transmission error and not to congestion. In such cases, the offered throughput should be reduced to 0.625 times its previous value.

When the user has reduced its rate due to frame loss, it may increase its rate by a factor of 0.125 after any S/2 consecutive frames are received with the BECN bit clear.

#### I.2.2.2.2 *Use of windows as an approximation to rate based control*

Users may use a window based mechanism as an approximation to rate based control.

Upon determining that a frame has been dropped, the user should reduce its current working window size to the greater of 0.25 times the previous value or 1.

If the network is known to be providing explicit congestion notification and no frames received during the prior window turn were received with the BECN bit set, there is a moderate likelihood that the frame loss is due to transmission error and not to congestion. In such cases, the working window size should be reduced to the greater of 0.625 times its previous value or 1.

The user may increase its working window size by 1 after any window turn in which no further frame loss is detected. If the current working window size is less than 8, the user may optionally increase its window size after receipt of five frames, rather than waiting for an entire window turn. These increase factors may be limited by the increase factors specified in § I.2.1.1 for explicit congestion notification.

*Note* – The use of window based mechanisms to approximate rate based control is reasonably accurate only if the statistical variance of the frame is relatively small.

### I.2.2.3 *Network procedures for setting the BECN bit*

The network should, if possible, set the BECN bit before it becomes necessary to discard frames. The network should continue to set the BECN bit whenever it is in such a condition and may elect to continue to send set BECN bits for some time after the congestion condition is removed.

If the congestion deteriorates, the network should discard frames sent in excess of throughput at the access node. Some networks may discard those frames marked with the DE bit = "1" in preference to other frames. At this stage, the network is in a moderately congested state and the BECN bits should continue to be set on frames which are not discarded.

If the congestion condition further deteriorates to the point that frames which are neither in excess of throughput nor are marked with the DE bit, are being discarded, a severe congestion condition exists. The network should continue to use the BECN to encourage users to reduce their rates, and may need to take further actions (e.g., clear or reroute calls) to restore control.

## I.2.3 *CLLM usage*

### I.2.3.1 *Network procedures for sending CLLM*

Section A.7.5 describes the actions of the congested node. The congested node must also keep edge nodes informed. In the case of a congestion situation, the network node sends the CLLM towards the source node. The cause code of the CLLM defines the reason for congestion and the edge node signals the user to initiate congestion control procedures. Since any or all nodes in the network may send CLLMs, multiple congestion conditions may affect a user's frame relaying connection through the network.

I.2.3.2 *Recommended behavior of the end user upon receipt of CLLM*

The end user is not allowed to generate CLLMs.

When the end user receives a CLLM, the end user follows the step/rate reduction procedures in § I.2.2.1.

I.2.3.3 *CLLM user response to implicit detection of congestion*

The end user reaction is described in § I.2.2.2.

## APPENDIX II

(to Recommendation Q.922)

**Signalling configurations**

Group signalling includes:

*Channel associated group signalling* – The condition where one logical link contains the signalling for the other logical links within the same channel; see Figure II-1/Q.922.

*Channel associated multiple group signalling* – The condition where two or more logical links each contain the signalling for non-overlapping subsets of the other logical links within the same channel, see Figure II-2/Q.922.

*Channel non-associated group signalling* – The condition where one logical link within a channel contains the signalling for logical links within another channel on the same facility. Within ISDN interfaces Recommendation (I.430 [4]/I.431 [16]) this implies D-channel control of links within a B-channel or H-channel on the same facility, see Figure II-3/Q.922.

*Facility*[1] *non-associated group signalling* – The condition where one logical link within a channel contains the signalling for logical link within a channel on a different interface. This type of signalling is only used if Channel Non-Associated Group Signalling is not used at an interface; see Figure II-4/Q.922.

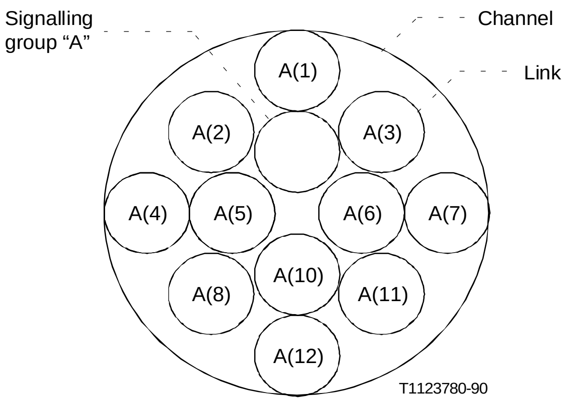



FIGURE II-1/Q.922

**Channel associated group signalling**

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[1] The term “facility” means a physical transmission path.

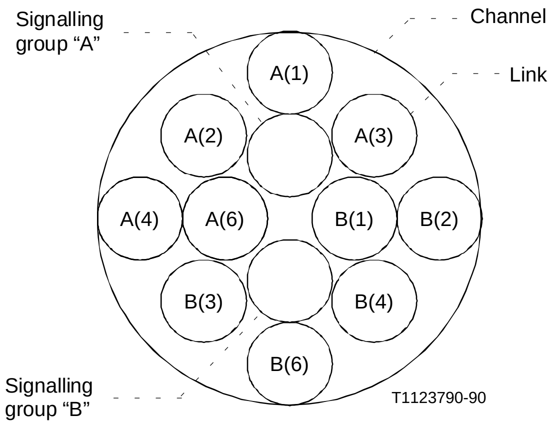


FIGURE II-2/Q.922

**Channel associated multiple group signalling**

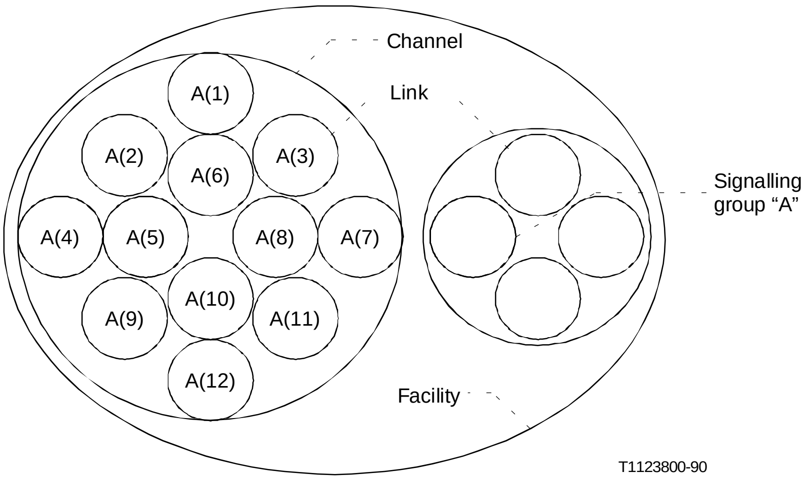


FIGURE II-3/Q.922

**Channel non-associated group signalling**

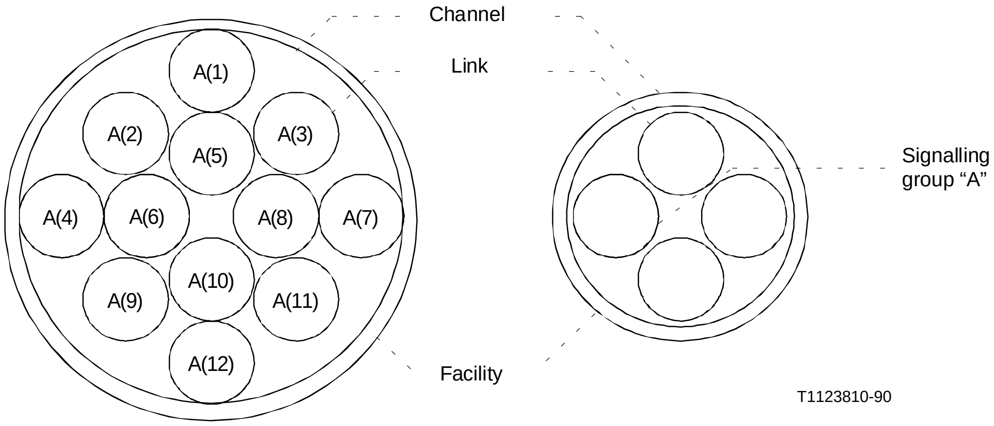


FIGURE II-4/Q.922

**Facility non-associated group signalling**

APPENDIX III

(to Recommendation Q.922)

**Automatic negotiation of data link layer parameters**

## III.1 *General*

Each data link layer entity has an associated data link connection management entity. The data link connection management entity has the responsibility for initializing the link parameters necessary for correct peer-to-peer information transport.

The method initialization of the parameters follows one of the two methods below:

– initialization to the default values as specified in § 5.9; or

– initialization based on the values supplied by its peer entity.

The latter method utilizes the parameter negotiation procedure described in this Appendix. Typically, after the assignment of a layer 2 address to the management entity, the data link connection management entity is notified by its layer management entity that parameter initialization is required.

The data link connection management entity will invoke the peer-to-peer notification procedure. After parameter initialization, the data link connection management entity will notify the layer management entity that parameter initialization has occurred, and the layer management entity will issue the MDL-ASSIGN request.

## III.2 *Parameter initialization*

The parameter initialization procedure may invoke either the internal initialization procedure or the automatic notification of data link parameter procedure.

## III.3 *Internal parameter initialization*

When the layer management entity notifies the connection management entity of layer 2 address assignment, the connection management entity shall initialize the link parameters to the default values and notify the layer management of task completion.

III.4 *Automatic notification of data link layer parameter values*

For each data link layer an exchange of certain data link layer parameters may take place between the peer data link connection management entities before entering the *TEI assigned* state. This exchange may be initiated after acquiring a layer 2 address.

The data link connection management entity, following assignment of a layer 2 address from the layer management entity, shall issue an XID command with the P-bit set to 0 and containing the parameter message shown in Figure III-1/Q.922, and start the connection management timer TM20.

The I field of the XID command frame shall reflect the parameters desired for future communications across this data link layer connection.

The peer data link connection management entity upon receipt of this XID command frame shall transmit an XID response with the F-bit set to 0 containing the list of parameter values that the peer can support.

If the data link connection management entity receives the above XID response prior to expiry of timer TM20, it shall stop the timer, and shall notify the layer management entity of a successful parameter exchange. However, if timer TM20 expires before receiving the XID response, the data link connection management entity shall retransmit the XID command, increment the retransmission counter and restart timer TM20. This retransmission process is repeated if timer TM20 expires again. Should the retransmission counter equal NM20, or an XID response frame with a zero length I field be received, the data link connection management entity shall issue an indication to the layer management entity and initialize the parameters to the default values. The layer management entity may log this condition, an then issue the MDL-ASSIGN-request primitive to the data link layer entity.

The timer TM20 is set to 2.5 seconds and NM20 is set to 3.

| Octet | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | Format identifier (FI) |
| 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Group identifier (GI) |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Group length (GL) |
| 8 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | Group length (GL) |
| 9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | PI = Frame size (transmit) |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | PL = 2 |
| 11 | $2^{15}$ | | | | | | | $2^8$ | PV = N201 value of transmitter |
| 12 | $2^7$ | | | | | | | $2^0$ | PV = N201 value of transmitter |
| 13 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | PI = Frame size (receive) |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | PL = 2 |
| 15 | $2^{15}$ | | | | | | | $2^8$ | PV = N201 value of receiver |
| 16 | $2^7$ | | | | | | | $2^0$ | PV = N201 value of receiver |
| 17 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | PI = Window size (transmit) |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | PL = 1 |
| 19 | 0 | $2^6$ | | | | | | $2^0$ | PV = k value |
| 20 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | PI = Retransmission timer (T200) |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | PL = 1 |
| 22 | $2^7$ | | | | | | | $2^0$ | PV = T200 value (Note) |

*Note* – Increments of 0.1 seconds; maximum range 25.5 seconds.

FIGURE III-1/Q.922

**Parameter message encoding**

APPENDIX IV

(to Recommendation Q.922)

## A convergence protocol to provide OSI-CONS above Q.922

### IV *General*

The following functions are required to be supported by the protocol above LAPF.

– segmentation and reassembly,

– reset,

– protocol discriminator,

– expedited data, and

– qualified data indication.

Proper operation of this convergence protocol requires the acknowledged mode of LAPF. The OSI data transfer phase is provided by a protocol that resides in the end systems and operates above the data link layer on the logical channel obtained during the connection establishment phase. This protocol supports the service described in Annex B of Recommendation I.233 [1].

The N-connection establishment is based on the reset function discussed in § IV.2.5. The N-connection release is implicit.

### IV.1 *Elements of the protocol*

This protocol consists of a one octet protocol discriminator field, a one octet control field and a data field (see Figure IV.1/Q.922). The collection of these fields is referred to as a "protocol unit" (PU). The encoding of the protocol discriminator field is to be selected by the appropriate standard bodies (i.e. ISO/IEC JTC/SC6 or CCITT SG VII). The control header consists of:

– a segmentation field (Sg);

– a reset field (RST);

– a qualified data indication field (Q);

– an expedited data confirmation field (XC);

– an expedited data indication field (X); and

– a header expansion field (E).

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
|---|---|---|---|---|---|---|---|---|
| Protocol discriminator field | | | | | | | | |
| E | X | XC | Q | RST | | Sg | | Control header |
| Data field | | | | | | | | |

FIGURE IV-1/Q.922

**Protocol unit**

### IV.1.1 *Segmentation field (Sg)*

The segmentation field is used to segment NS-user-data when its length exceeds N301 (N301 is the maximum permissible length of the data field in octets). The segmentation field consists of bits 1 and 2 of the control header. This field is interpreted according to Table IV-1/Q.922.

TABLE IV-1/Q.922

**Segmentation field encoding**

| Bit 2 | Bit 1 | Interpretation |
|---|---|---|
| 0 | 0 | Data field has one of the middle segments of NS-user-data |
| 0 | 1 | Data field has the beginning segment of NS-user-data |
| 1 | 0 | Data field has the final segment of NS-user-data |
| 1 | 1 | Data field has the complete unsegmented NS-user-data |

### IV.1.2 *Reset (RST)*

The reset field is used to indicate a reset to the peer entity, or to provide a confirmation to the peer entity that a reset has occurred. The RST field consists of bits 3 and 4 of the control header. This field is interpreted according to Table IV-2/Q.922,

TABLE IV-2/Q.922

**Reset field encoding**

| Bit 4 | Bit 3 | Interpretation |
|---|---|---|
| 0 | 0 | No reset is requested |
| 0 | 1 | Reset is requested |
| 1 | 0 | Reset is confirmed |
| 1 | 1 | Not used |

When the RST field is set to “01”, the data field shall only contain information about the originator and the cause of the reset. The formats and encodings of the originator and cause fields are for further study. When the RST field is set to “10”, the data field shall be empty.

### IV.1.3 *Expedited data indication field (X)*

The expedited data indication field is used to indicate that the data field contains expedited NS-user-data. The X field consists of bit 7 of the control header. The field is interpreted in accordance with Table IV-3/Q.922. When the X field is set to “1”, the maximum length of the data field is 32 octets.

TABLE IV-3/Q.922

**Expedited data indication field encoding**

| Bit 7 | Interpretation |
|---|---|
| 0 | Not expedited NS-user-data |
| 1 | Expedited NS-user-data |

### IV.1.4 *Expedited confirmation field (XC)*

The expedited data confirmation field is used to confirm the receipt of expedited NS-user-data. The XC field consists of bit 6 of the control header. This field is interpreted in accordance with Table IV-4/Q.922.

TABLE IV-4/Q.922

**Expedited data confirmation field encoding**

| Bit 6 | Interpretation |
|---|---|
| 0 | No expedited NS-user-data confirmed |
| 1 | Expedited NS-user-data confirmed |

### IV 1.5 *Qualified data indication field (Q)*

The qualified data indication field is used to indicate that the PU contains qualified data requiring special treatment. The Q field consists of bit 5 of the control header. This field is interpreted in accordance with Table IV-5/Q.922.

TABLE IV-5/Q.922

**Qualified data indication field encoding**

| Bit 5 | Interpretation |
|---|---|
| 0 | Normal NS-user-data |
| 1 | Qualified NS-user-data |

IV.1.6 *Header extension field (E)*

The header extension field is used to extend the control header beyond the present two octets. The E field consists of bit 8 of the control header. The field is interpreted in accordance with Table IV-6/Q.922

TABLE IV-6/Q.922

**Header extension field encoding**

| Bit 8 | Interpretation |
|---|---|
| 0 | Control header is extended |
| 1 | Control header is not extended |

This field shall be set to "1". The extension of the control header, if necessary, may be specified by this Recommendation in the future.

IV.1.7 *System parameters*

There are three system parameters used in this protocol. They are:

– N301, the maximum length of the data field;

– N300, the maximum number of retransmissions; and

– T300, the retransmission timer.

The default values for these parameters are:

– N300 = 3 (N200),

– N301 = 258 (260 - 2),

– T300 = 2 sec (> T200).

In addition, three markers are used in this protocol. They are:

– the expedited-data-sent marker, used to denote that expedited NS-user-data has been sent and a confirmation is expected;

– the reset-sent marker, used to denote that a reset has been transmitted and confirmation is expected; and

– the no-N-RESET confirm marker, used to denote that no N-RESET confirm primitive should be issued upon the receipt of a protocol unit with the RST field set to "10" or the RST field set to "01". This applies to a Network service provider invoked RESET and to RESET collisions; however, for an RST field set to "01", an N-RESET indication primitive shall be issued (see § IV.2.5).

IV.2 *Protocol procedures*

IV.2.1 *Normal data*[2)]

Upon receiving an N-DATA request primitive, a protocol unit containing the NS-user-data shall be transmitted, following any protocol units that are already queued. If the length of the NS-user-data field exceeds N301 octets, it shall be segmented in accordance with the procedures of § IV.2.4.

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2) The term "normal data" is used here to refer to NS-user-data that is not expedited and not qualified.

Upon receiving a PU containing normal data and with the Sg field set to “11”, an N-DATA indication primitive shall be issued containing the NS-user-data following any primitives in progress. Otherwise, the procedure described in § IV.2.4 shall be followed before the N-DATA indication primitive is issued.

IV.2.2 *Expedited data*

Upon receiving an N-EXPEDITED-DATA request primitive, a PU with the X field set to “1” and the data field containing the expedited NS-user-data shall be transmitted immediately following any protocol unit that is being transmitted (but ahead of any PUs queued but not yet being transmitted), timer T300 is started, retransmission counter variable (RC) is set to “0”, the expedited-data-sent marker shall be set, and the expedited NS-user-data shall be buffered until the marker is cleared, in accordance with the following condition:

– if the length of the expedited NS-user-data exceeds 32 octets, the expedited NS-user-data shall be discarded and the connection[3)] shall be reset in accordance with the procedure described in § IV.2.5.

*Note* – Expedited Data Transfer is an end-to-end capability.

Upon receiving a PU with the X field set to “1”, an N-EXPEDITED-DATA indication primitive containing the expedited NS-user-data shall be issued immediately following any primitive that is being issued (but ahead of any primitives queued but not yet issued), and an expedited-data confirmation (XC field set to “1”) shall be transmitted at the earliest opportunity in accordance with the following condition:

– if the length of the expedited NS-user-data exceeds 32 octets, the PU shall be discarded and the connection shall be reset in accordance with the procedure described in § IV.2.5.

Expedited data confirmation can be transmitted in a dedicated PU or included in a PU used to transmit normal, expedited, or qualified data.

Upon receiving a PU with the XC field set to “1”, the Expedited-data sent marker shall be cleared. If no Expedited-data sent marker is set, the PU shall be processed as though the XC field was set to “0”.

Upon expiry of timer T300, a PU with the X field set to “1” and the data field containing the expedited NS-user-data shall be retransmitted as per the procedures described above. After N300 retransmissions, the reset procedures of § IV.2.5 are initiated.

IV.2.3 *Qualified data*

When this protocol is used to interwork with Recommendation X.25, special data not intended for layer 4 may need to be transmitted. In such a case, upon receiving such data, a PU with the Q field set to “1” containing the qualified data shall be transmitted, following any PU already queued. If the length of the qualified data exceeds N301 octets, it shall be segmented in accordance with the procedures described in § IV.2.4. If the qualified data is segmented the Q field of all segments shall be set to “1”.

Upon receiving a PU with the Q bit set to “1”, the qualified data shall be forwarded to the appropriate entity responsible for processing it. If the qualified data is segmented, the procedures described in § IV.2.4 shall be followed.

If no appropriate entity exists to receive qualified data, the contents of the data field shall be discarded.

IV.2.4 *Segmentation and reassembly*

Upon receiving an N-DATA request primitive (or a request to send qualified data) containing an NS-user-data field (or qualified data) with length exceeding N301, the NS-user-data (or qualified data) shall be

———————

3) The term "connection" is used here to refer to an instance of communications between the peer entities.

segmented into segments equal to N301 or smaller (when there is not enough data left) and shall be transmitted in accordance with the following:

- the Sg field in the PU containing the first segment of the NS-user-data (or qualified data) shall be set to “01”,
- the Sg field in the PU containing the middle segments of the NS-user-data (or qualified data) shall be set to “00”,
- the Sg field in the PU containing the final segment of the NS-user-data (or qualified data) shall be set to “10”.

Upon receiving a PU with the Sg field set to “01”, the reassembly process shall be started and NS-user-data shall be accumulated.

Upon receiving a PU with the Sg field set to “01” or “11”, if previous NS-user-data (or qualified data) is in the process of being accumulated but not yet completed, it shall be discarded and the connection shall be reset in accordance with the procedures described in § IV.2.5.

Upon receiving a PU with the Sg field set to “00”, the contents of the data field shall be added to the NS-user-data that is being accumulated in accordance with the following conditions:

- if there is no NS-user-data (or qualified data) being accumulated, the NS-user-data (or qualified data) segment shall be discarded and the connection shall be reset in accordance with the procedure described in § IV.2.5.
- if the Q field is not identical to the Q field of the previous segments, the accumulated NS-user-data (or qualified data) shall be discarded and the connection shall be reset in accordance with the procedure described in § IV.2.5.

Upon receiving a PU with the Sg field set to “10”, the contents of the data field shall be added to the NS-user-data that is being accumulated and an N-DATA indication primitive shall be issued (in the case of normal data), or the accumulated data shall be delivered to the special protocol entity (in the case of qualified data), in accordance with the following conditions:

- if there is no NS-user-data (or qualified data) being accumulated, the NS-user-data (or qualified data) segment shall be discarded and the connection shall be reset in accordance with the procedure in § IV.2.5.
- if the Q field is not identical to the Q field of the previous segments, the accumulated NS-user-data (or qualified data) shall be discarded, and the connection shall be reset in accordance with the procedure in § IV.2.5.

If a PU with an X field set to “1” is received at any time during the accumulation of a segmented NS-user-data, an N-EXPEDITED-DATA indication primitive containing the expedited NS-user-data shall be issued and the accumulation of the segmented NS-user-data shall continue

If a DL-ESTABLISH indication primitive is received during the reassembly of NS-user-data, the partially assembled segments shall be discarded and an NS-provider invoked RESET shall be invoked.

### IV.2.5 *Reset*

A reset procedure shall be invoked:

- upon receipt of an N-RESET request primitive (for an NS-user invoked reset);
- upon receipt of a DL-ESTABLISH indication primitive while in an information transfer state (for an NS-provider invoked reset);
- upon detection of a protocol error or an erroneous control header field encoding.

Upon initiation of the reset procedures, any PUs that are being transmitted shall be aborted, T300 shall be started, RC shall be set to zero, all existing queues and registers shall be cleared, and a PU with the RST field set to “01” (reset request) shall be transmitted, the Reset-sent marker shall be set, and any received PU other than one with an RST field set to “10” shall be discarded until the Reset-sent marker is cleared. In the case of an NS-provider invoked reset, the No-N-RESET confirm marker shall be set.

Upon receiving a PU with the RST set to “01” while there is no outstanding reset, all timers shall be stopped, all existing queues and registers shall be cleared, and an N-RESET indication primitive shall be issued. However, if the data field of the PU contains unrecognizable originator and/or cause fields, the parameters for originator and cause in the N-RESET indication primitive are undefined, as is appropriate.

Upon receiving an N-RESET response primitive, a PU with the RST field set to “10” shall be transmitted at the earliest opportunity.

Upon receiving a PU with the RST field set to “10”, timer T300 shall be stopped, the Reset-sent marker shall be cleared, and:

– if the No-N-RESET confirm marker is not set, an N-RESET confirm primitive shall be issued at the earliest opportunity;

– if the No-N-RESET confirm marker is set, no primitives shall be issued (see § IV.1.2.), in accordance with the following condition;

– if a data field is included in the PU, the PU shall be discarded and the connection shall be reset.

Upon expiration of timer T300, the PU with the RST field set to “01” shall be transmitted, T300 shall be restarted, and RC shall be increased and the Reset-sent marker shall be set. If RC has reached its maximum permissible value (N300), the connection shall be released.

Any PU received with the RST field set to “11” (a protocol error) shall be discarded and the connection shall be reset.

For the purpose of synchronization at the beginning of communication, or for resynchronization after the occurrence of certain error conditions, the connection shall be reset. A protocol unit with the RST field set to “01” shall be transmitted, T300 shall be started, and the Reset-sent and the No-N-RESET confirm markers shall be set to reflect the case of NS-provider invoked reset. At the beginning of communication, no N-RESET indication primitive shall be issued (see Note), otherwise an N-RESET indication primitive shall be issued.

*Note* – At the beginning of the communication, the NC endpoint is in state 2 according to Figure 5/X.213 [5]. No N-RESET primitive is permitted in this state

If an N-RESET request primitive is received at the same time as a PU with the RST field set to “01”, all timers shall be stopped, all existing queues and registers shall be cleared, an N-RESET confirm primitive shall be issued, and a PU with the RST field set to “10” shall be transmitted.

If a PU with the RST field set to “01” is received after a PU with RST set to “01” is transmitted (but before it is confirmed), a reset collision occurred. Then a PU with RST set to “01” shall be transmitted. The Reset-sent marker shall be cleared, an N-RESET confirm primitive shall be issued, and timer T300 shall be stopped after receiving a PU with RST set to “10”.

### IV.2.6 *Header error conditions*

Table IV-7/Q.922 depicts all possible codings of the control header octet. The c character indicates an appropriate use of the control header. The n character is used to indicate that the coding of the field (column or row) is not permitted by this protocol. The r character is used to indicate that the field occupying a column is inappropriately coded, given the coding of the field occupying the associated row (or vice versa).

When a PU is received with a control header coded inappropriately (i.e., n or r), the PU shall be discarded and the connection shall be reset in accordance with the procedure described in § IV.2.5.

TABLE IV-7/Q.922

**Possible control header combinations**

| | | E | | Q | | X | | XC | | RST | | | | Sg | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 00 | 01 | 10 | 11 | 00 | 01 | 10 | 11 |
| E | 0 | | | n | n | n | n | n | n | n | n | n | n | n | n | n | n |
| | 1 | | | c | c | c | c | c | c | c | c | c | n | c | c | c | c |
| Q | 0 | n | c | | | c | c | c | c | c | c | c | n | c | c | c | c |
| | 1 | n | c | | | c | r | c | c | c | r | r | n | c | c | c | c |
| X | 0 | n | c | c | c | | | c | c | c | c | c | n | c | c | c | c |
| | 1 | n | c | c | r | | | c | c | c | r | r | n | r | r | r | c |
| XC | 0 | n | c | c | c | c | c | | | c | c | c | n | c | c | c | c |
| | 1 | n | c | c | c | c | c | | | c | r | r | n | c | c | c | c |
| RST | 00 | n | c | c | c | c | c | c | c | | | | | c | c | c | c |
| | 01 | n | c | c | r | c | r | c | r | | | | | r | r | r | c |
| | 10 | n | c | c | r | c | r | c | r | | | | | r | r | r | c |
| | 11 | n | c | n | n | n | n | n | n | | | | | n | n | n | n |
| Sg | 00 | n | c | c | c | c | r | c | c | c | r | r | n | | | | |
| | 01 | n | c | c | c | c | r | c | c | c | r | r | n | | | | |
| | 10 | n | c | c | c | c | r | c | c | c | r | r | n | | | | |
| | 11 | n | c | c | c | c | c | c | c | c | c | c | n | | | | |

c Correct use of the control header

n Coding that is not permitted

r Erroneous use of control header fields

APPENDIX V

(to Recommendation Q.922)

**Occurrence of MDL-ERROR indication within the basic states**

## V.1 *Introduction*

Table V-1/Q.922 gives the error situations in which the MDL-ERROR indication primitive will be generated. This primitive notifies the data link layer’s connection management entity of the occurred error situation. The associated error parameter contains the error code that describes the unique error conditions.

This Appendix does not incorporate the retransmission of REJ response frames described in Appendix I of Recommendation Q.921 [2].

## V.2 *Layout of Table V-1/Q.922*

The “error code” column gives the identification value of each error situation to be included as a parameter with the MDL-ERROR indication primitive.

The column entitled “Error condition” together with the column “Affected states” describes unique protocol error events and the basic state of the data link layer entity at the point that the MDL-ERROR indication primitive is generated.

In the described error situations, the action to be taken by the layer management entity is implementation dependent. “Implementation dependent” means that it is optional whether the layer management has incorporated any form of error counter to log (store) the reported event. If action is taken, the layer management has to take into account that the data link layer will have initiated a recovery procedure.

TABLE V-1/Q.922

**MDL-ERROR indications**

| Error type | Error code | Error condition | Affected states (Note 1) |
|---|---|---|---|
| Receipt of unsolicited response | A | Supervisory (F = 1) | 7 |
| | B | DM (F = 1) | 7, 8 |
| | C | UA (F = 1) | 4, 7, 8 |
| | D | UA (F = 0) | 4, 5, 6, 7, 8 |
| | E | Receipt of DM response (F = 0) | 7, 8 |
| Peer initiated re-establishment | F | SABME | 7, 8 |
| Unsuccessful retransmission (N200 times) | G | SABME | 5 |
| | H | DISC | 6 |
| | I | Status enquiry | 8 |
| Other | J | N(R) error | 7, 8 |
| | K | Receipt of FRMR response | 7, 8 |
| | L | Receipt of non-implemented frame | 4, 5, 6, 7, 8 |
| | M (Note 2) | Receipt of I field not permitted | 4, 5, 6, 7, 8 |
| | N | Receipt of frame with wrong size | 4, 5, 6, 7, 8 |
| | O | N201 error | 4, 5, 6, 7, 8 |

*Note 1* – For the description of the affected states, see Annex B

*Note 2* – According to § 5.8.5, this error code will never be generated.

APPENDIX VI

(to Recommendation Q.922)

## Abbreviations and acronyms used in this Recommendation

| *Abbreviation or acronym* | *Meaning* |
|---|---|
| ASP | Assignment source point |
| BECN | Backward explicit congestion notification |
| C/R | Command/response field bit |
| CEI | Connection endpoint identifier |
| CLLM | Consolidated link layer management message |
| CTD | Cumulative transit delay |
| D/C | DLCI/Data link core control indicator |
| DE | Discard eligibility indicator |
| DISC | Disconnect |
| DL- | Communication between layer 3 and data link layer |
| DL-CORE- | Communications between the DL-CORE user and the DL-CORE |
| DLCI | Data link connection identifier |
| DM | Disconnected mode |
| E | Header expansion field |
| EA | Address field extension bit |
| FCS | Frame check sequence |
| FECN | Forward explicit congestion notification |
| FI | Format identifier |
| FMBS | Frame mode bearer service |
| FRMR | Frame reject |
| GI | Group identifier |
| GL | Group length |
| I | Information |
| ISDN | Integrated services digital network |
| ISO | International Standard Organization |
| k | Maximum number of outstanding I frames |
| L1 | Layer 1 |
| L2 | Layer 2 |
| L3 | Layer 3 |
| LAN | Local area network |

| *Abbreviation or acronym* | *Meaning* |
|---|---|
| LAPD | Link access procedure on the D-channel |
| LAPF | Link access procedure for frame mode bearer services |
| M | Modifier function bit |
| M2N- | Communication between layer 3 and layer 2 |
| MC | Communication between DL-CORE and layer 2 management |
| MDL- | Communication between management entity and the data link layer |
| N(c) | Network layer for the control plane |
| N(R) | Receive sequence number |
| N(S) | Send sequence number |
| N(u) | Network layer for the user plane |
| OSI | Open systems interconnection |
| P/F | Poll/Final bit |
| PDU | Protocol data unit |
| PH- | Communication between data link layer and physical layer |
| PI | Parameter identifier |
| PL | Parameter length |
| PU | Protocol unit |
| PV | Parameter value |
| Q | Qualified data indication field |
| RC | Retransmission counter |
| REC | Receiver |
| REJ | Reject |
| RNR | Receive not ready |
| RR | Receive ready |
| RST | Reset field |
| RTD | Round trip delay |
| S | Supervisory |
| SABME | Set asynchronous balanced mode extended |
| SAP | Service access point |
| SCF | Synchronization and convergence function |
| SDL | Specification and description language |

| *Abbreviation or acronym* | *Meaning* |
|---|---|
| Sg | Segmentation field |
| SREJ | Selective reject |
| Su | Supervisory function bit |
| TEI | Terminal endpoint identifier |
| TX | Transmit |
| U | Unnumbered |
| UA | Unnumbered acknowledgement |
| UI | Unnumbered information |
| V(A) | Acknowledge state variable |
| V(k) | Current working window size |
| V(M) | Recovery state variable |
| V(R) | Receive state variable |
| V(S) | Send state variable |
| X | Expedited data indication field |
| XC | Expedited data confirmation field |
| XID | Exchange identification |

**References**


[1] CCITT Recommendation I.223 – *Frame mode bearer services*

CCITT Recommendation I.233.1 – *ISDN frame relaying bearer service*

CCITT Recommendation I.233.2 – *ISDN frame switching bearer service*

[2] CCITT Recommendation Q.921 – *ISDN user-network interface-Data link layer specification.*

[3] CCITT Recommendation Q.933 – *Digital subscriber Signalling System No. 1 (DSS1) - Signalling specification or frame mode bearer service.*

[4] CCITT Recommendation I.430 – *Basic user-nework interface-Layer 1 specification*.

[5] CCITT Recommendation X.213 – *Network service definition for open systems interconnection for CCITT applications.*

[6] CCITT Recommendation X.25 – *Interface between data terminal equipment (DTE) and data circuit terminating equipment (DCE) for terminals operating in the packet mode and connected to a public data network by dedicated circuit.*

[7] CCITT Recommendation Q.920 – *ISDN user-network interface data link layer - General aspects.*

[8] CCITT Recommendation X.212 – *Data link service definition for open systems interconnection for CCITT applications.*

[9] CCITT Recommendation X.211 – *Physical service definition of open systems interconnection for CCITT applications.*

[10] CCITT Recommendation I.370 – *Congestion management for the ISDN frame relaying bearer service.*

[11] CCITT Recommendation I.122 – *Framework for providing additional packet mode bearer services*

[12] CCITT Recommendation X.200 – *Reference model of open systems interconnection for CCITT applications.*

[13] CCITT Recommendation X.210 – *Open systems interconnection layer service definition conventions.*

[14] CCITT Recommendation I.320 – *ISDN protocol reference model.*

[15] ISO 8885 – *Information technology – Telecommunications and information exchange between systems* - *High level data link control (HDLC) procedures* - *General purpose XID frame information field content and format.*

[16] CCITT Recommendation I.431 – *Primary rate user* - *network interface-Layer 1 specification.*